ASPEN

The 10th International Conference of Asian Society for Precision Engineering and Nanotechnology

Conference Proceedings

ASPEN 2023

21-24 November 2023

Hong Kong

Organized by

The Hong Kong Polytechnic University 香港理工大學

Department of Industrial & Systems Engineering 工業及系統工程學系

SKL

Hong Kong Society for Precision Engineering

Co-organized by

中国机械工程学会 CHINESE MECHANICAL ENGINEERING SOCIETY

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Leading Optics Manufacturing

Leading Optics is a high-technology company focusing on the development of nanometer-level ultra-precision manufacturing equipment and mass production of micro-nano structured optics. The company possesses a comprehensive manufacturing system covering optical design, core process development, ultra-precision manufacturing, optical coating, and large-scale production.

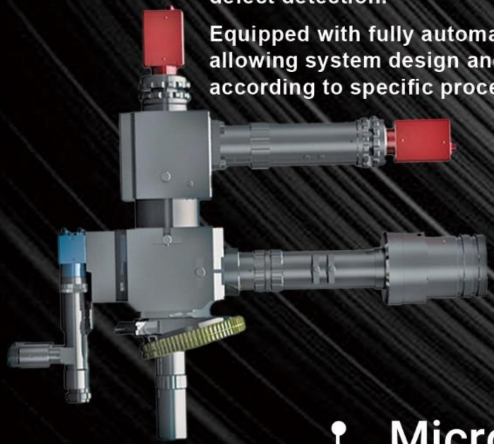
Its products are extensively utilized in various fields, including integrated circuits, biomedical applications, intelligent automotive systems, and consumer electronics.

Optomechanical System

Integrated with auto-foucs module based on white light interometry, wide-field imaging system, and high-resolution microscopy imaging system.

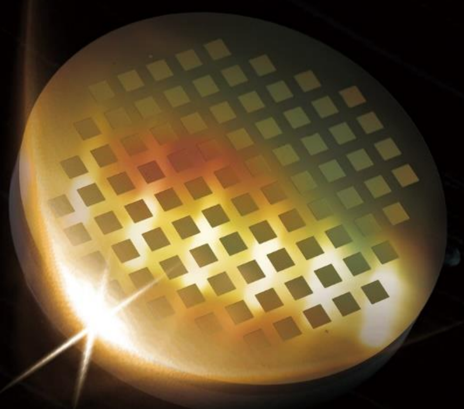
Capable of rapid, stable, and accurate measurement of critical dimensions and alignment accuracy, as well as defect detection.

Equipped with fully automated measurement functions, allowing system design and parameters to be optimized according to specific processes.



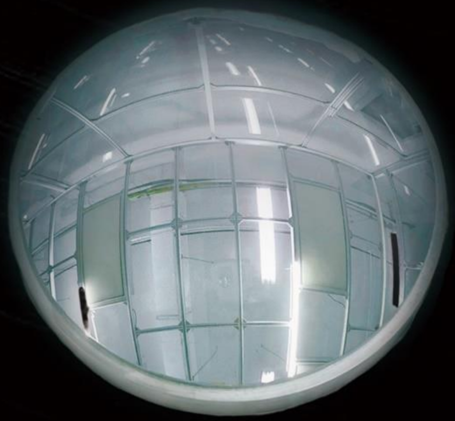
Microlens array

Leading Optics has the capability for optical design, mold manufacturing, and mass production of micro lens arrays, enabling wafer-level optical manufacturing. The products are primarily used in optical imaging systems, laser applications, and other fields.



large aperture optics element

Leading Optics possesses the capability for the mass production of large-aperture and high-precision optical components. The products are widely used in high-precision optical measurement systems, precision lenses, laser applications, and so on.



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Welcoming Address

Welcome to the 10th International Conference of the Asian Society for Precision Engineering and Nanotechnology (ASPEN 2023) hosted by the State Key Laboratory of Ultra-precision Machining Technology of The Hong Kong Polytechnic University (PolyU). It is my great pleasure to address the opening of this event.

Precision Engineering and Nanotechnology form the backbone and support of today's innovative technology industries ranging from optoelectronics and mechatronics, optics, and telecommunications to biomedical engineering. ASPEN as a union of academic and professional societies in Asia focuses on Precision Engineering and Nanotechnology. It has been 12 years since ASPEN 2011 which was last held by PolyU. I am very happy that everyone is coming to Hong Kong and PolyU again. The conference aims to bring together researchers and academics in the Asia-Pacific region to discuss new research, novel theories, technologies and applications in the areas of precision engineering and nanotechnology.

Over the past 85 years, more than a quarter of a million individuals have graduated from the University. PolyU emphasizes professional education, basic and translational research as well as local and global partnership. We are committed to creating and transferring technology and know-how with application value to the wider world in various ways. The University's unwavering commitment to excellence has earned it international recognition, with PolyU consistently ranking among the top 100 universities worldwide. Based on this solid foundation, the University will continue to make positive contributions in collaboration with its strategic partners for the betterment of Hong Kong, our nation, and the world.

Building upon the research strength of the tertiary education sector in Hong Kong, its vibrant entrepreneurship and good infrastructure, the government's efforts to re-vitalize Hong Kong's industries and foster the production of high-value-added and high-tech products and services are being successfully realized. It is nice to see the State Key Laboratory of Ultra-precision Machining Technology strengthening collaboration in the Asia-Pacific region and academic exchanges among experts and researchers in the field of Precision Engineering and Nanotechnology.

I wish the conference every success and all of you a happy stay in Hong Kong.

Professor Christopher Chao
Vice President (Research and Innovation)
Chair Professor of Thermal and Environmental Engineering
Director of Policy Research Centre for Innovation and Technology
The Hong Kong Polytechnic University
November 2023

Message from the President of the ASPEN and Conference Chairman

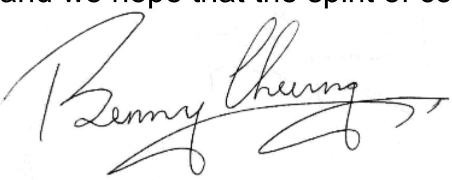
On behalf of the Asian Society for Precision Engineering and Nanotechnology (ASPEN) and the Conference Organizing Committee, I would like to welcome all of you to the 10th International Conference of the Asian Society for Precision Engineering and Nanotechnology (ASPEN2023) which will be held in Hong Kong from 21 Nov to 24 Nov 2023.

ASPEN stands for the Asian Society for Precision Engineering and Nanotechnology, which is organized as a union of academic and professional societies in Asia to promote networking and collaboration among scientists, researchers, and industry partners in the Asia-Pacific region for precision engineering and nanotechnology. The 1st ASPEN conference was held in Shenzhen, China in 2005 while the 4th ASPEN conference was held in Hong Kong in 2011. After 12 years, the 10th conference is now coming back to Hong Kong and is organized by the State Key Laboratory of Ultra-precision Machining Technology (SKL of UMT) of The Hong Kong Polytechnic University. The SKL of UMT has been actively engaging in the cutting-edge research related to precision engineering and nanotechnology which include ultra-precision machining, precision metrology, micro/nano-manufacturing, measurement and instrumentation, fabrication of ultra-precision freeform and structured surfaces, etc.

The Asia-Pacific is one of the fastest growing regions in terms of economics, education and technology. We are so glad to witness an increase in the number of scientists, engineers, academics as well as research institutes and companies involved in the research communities of Precision Engineering and Nanotechnology as compared with that ten years ago. The theme of this conference provides an excellent opportunity and platform for academics and industries to discuss and exchange ideas and their research findings, but also enable them to acquire knowledge of the latest development of Precision Engineering and Nanotechnology.

We have cordially invited internationally well-known experts from different Asian countries to deliver plenary speeches, session keynotes and invited talks as well as a number of companies supporting our Conference to showcase their latest research achievements, technologies and products.

We would like to express our sincere thanks to the co-organizers and sponsors for their support in the organization of the conference. We would also like to express our sincere thanks to the Hong Kong Tourism Board of the Government of the Hong Kong Special Administrative Region, for their hospitality in receiving our delegates to the conference. I hope that all of you will enjoy the event and we hope that the spirit of collaboration among us will continue in the years to come.



Professor Benny C.F. Cheung
President of the Asian Society for Precision Engineering and Nanotechnology (ASPEN)
Conference Chairman
Chair Professor of Ultra-precision Machining and Metrology
Director of the State Key Laboratory of Ultra-precision Machining Technology
Department of Industrial and Systems Engineering
The Hong Kong Polytechnic University

Conference Committee

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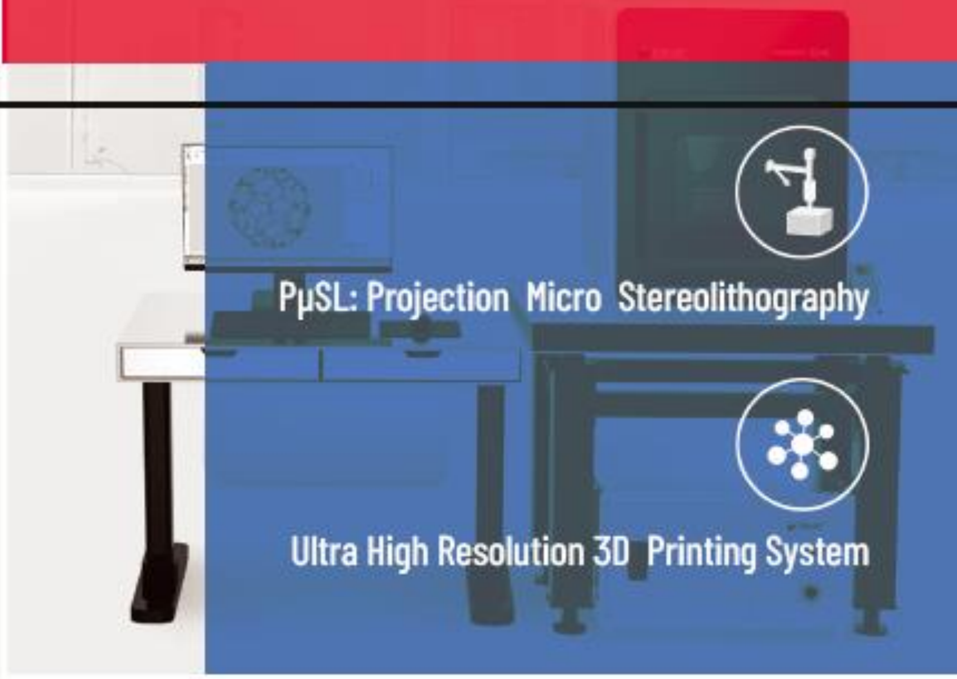

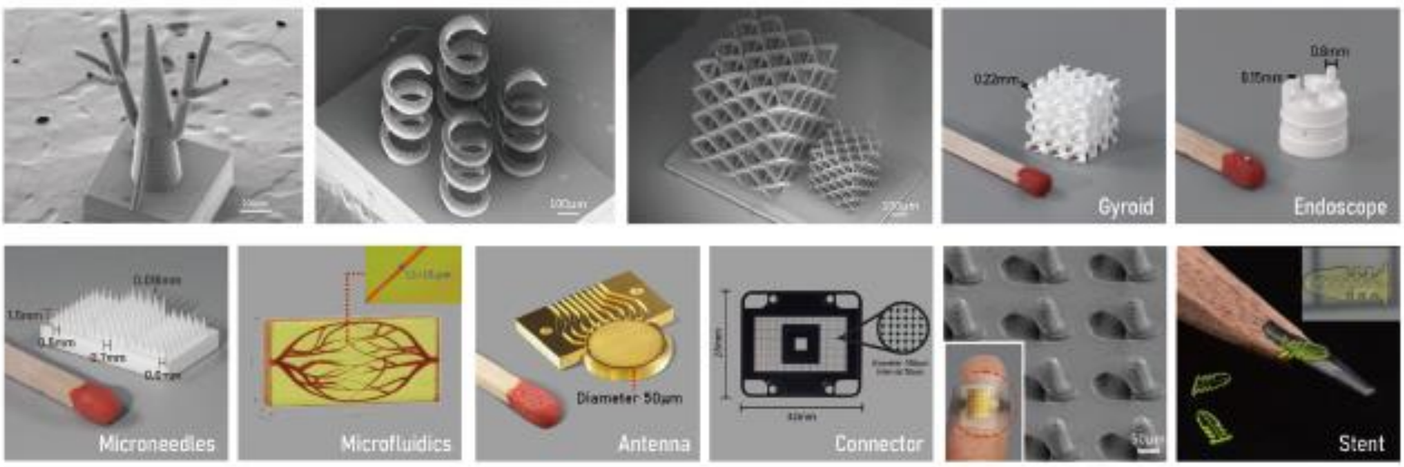

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Overview Schedule

21 November 2023, Tuesday	
Venue: Ju Yin House Seafood Restaurant, 4/F, Communal Building, The Hong Kong Polytechnic University	
17:30-20:00	Registration with *welcome reception (18:00-20:00)*

22 November 2023, Wednesday	
Venue: Hotel ICON 1/F, Silverbox Ballroom (Registration: 08:15-08:30)	
08:30-08:45	**Opening Ceremony** **Welcoming address by** 1. **Yu Hang Christopher Chao,** *Vice President (Research and Innovation), The Hong Kong Polytechnic University* 2. **Fengzhou Fang,** *CIRP President, Tianjin University* 3. **Chi Fai Benny Cheung,** *ASPEN President, Conference Chair of ASPEN, Director of SKL-UPMT, The Hong Kong Polytechnic University*
Plenary Session I (Session Chair: Chi Fai Benny Cheung, The Hong Kong Polytechnic University)	
08:45-09:25	**Damage-free Finishing of Optical Crystal Surfaces by Means of Plasma Modification** *Fengzhou Fang, Tianjin University*
09:25-10:05	**Digital Transformation of Machining Process** *Dong Yoon Lee, Korea Institute of Industrial Technology*
Tea/coffee Break (10:05-10:30)	
Plenary Session II (Session Chair: Sandy To, The Hong Kong Polytechnic University)	
10:30-11:10	**A Study on the Development of a Smart Manufacturing Framework** *Senthil Kumar Anantharajan, National University of Singapore*
11:10-11:50	**Fabrication and Field Emission Characteristic of Carbon-Based Nano Composite Materials** *Hung-Yin Tsai, National Tsing Hua University*
Lunch Break (11:50-13:30, Venue: Hotel ICON 1/F)	
13:00-14:00	**Industrial Session**
Plenary Session III (Session Chair: Wing Bun Rongbin Lee, The Hong Kong Polytechnic University)	
14:00-14:40	**From Precision to 'Precisions' – a Research Journey and the Lessons Learned** *Tien-Fu Lu, The University of Adelaide*
14:40-15:20	**Multiscale manufacturing: From Structures to Functions** *Zuankai Wang, The Hong Kong Polytechnic University*
Tea/coffee Break (15:20-15:45)	
15:45-17:30	**Technical visit I (Venue: The Hong Kong Polytechnic University)** *Please register at the reception desk (Max. 80 people, on a first come, first served basis)*
17:30-19:30	**Young Researcher Networking** **Venue:** Tack Hsin Restaurant, 2/F, Peninsula Centre, No. 67 Mody Rd, Tsim Sha Tsui East

23 November 2023, Thursday			
Venue: Hotel ICON 1/F, Silverbox Ballroom (Registration: 08:15-08:30)			
	Room 1	*Room 2*	*Room 3*
08:30-10:30	**Micro/Nano Fabrication Processes (I)**	**Atomic and Close-to-atomic Scale Manufacturing**	**High speed and Precision Machining (I)**
Tea/coffee Break (10:30-10:45)			
10:45-12:45	**Micro/Nano Fabrication Processes (II)**	• **Metrology (I)** • **IoT/AI/Big Data in Manufacturing**	**Manufacturing Systems and Machine Tools**
Lunch Break (12:45-13:45, Venue: Hotel ICON 1/F)			
13:45-16:00	**Micro/Nano Fabrication Processes (III)**	• **Bio/ Optical/ Medical Manufacturing & Applications (I)** • **Automation, Mechatronics, and Robotics**	**Additive Manufacturing (I)**
Tea/coffee Break (16:00-16:15)			
16:15-18:15	**Micro/Nano Fabrication Processes (IV)**	**Metrology (II)**	**Molding and Forming Technology**
18:30	**Banquet** **Venue:** Victoria Harbour Supreme 9/F, 1 Peking Road, Tsim Sha Tsui		

24 November 2023, Friday			
Venue: Hotel ICON 1/F, Silverbox Ballroom (Registration: 08:15-08:30)			
Plenary Session IV (Session Chair: Hideki Aoyama, Keio University)			
08:30-09:10	**Ultimate Condensation of X-ray Free Electron Laser down to Single Nanometer Size by Precision Mirror Devices** *Yamauchi Kazuto, Osaka University*		
	Room 1	*Room 2*	*Room 3*
09:15-11:00	**Non-traditional Machining (I)**	**Metrology (III)**	**High speed and Precision Machining (II)**
Tea/coffee Break (11:00-11:15)			
11:15-13:00	**Non-traditional Machining (II)**	**Metrology (IV)**	**Additive Manufacturing (II)**
Lunch Break (13:00-14:00, Venue: Hotel ICON 1/F)			
14:00-16:00	**Non-traditional Machining (III)**	**Metrology (V)**	**Bio / Optical/ Medical Manufacturing & Applications (II)**
16:00-17:30	**Technical visit II (Venue: The Hong Kong Polytechnic University)** *Please register at the reception desk (Max. 80 people, on a first come, first served basis)*		

23 November 2023 – Detailed Program

Time	Event		
	Room 1	**Room 2**	**Room 3**
	Micro/Nano Fabrication Processes (I)	Atomic and Close-to-atomic Scale Manufacturing	High Speed and Precision Machining (I)
Session Chair	Julong Yuan, Zhejiang University of Technology Jiang Guo, Dalian University of Technology	Renke Kang, Dalian University of Technology Rong Chen, Huazhong University of Science and Technology	Bi Zhang, Southern University of Science and Technology Xichun Luo, University of Strathclyde
08:30-08:55	*Session Keynote Speech* Force Rheological Polishing Technology and Its Research Progress **Julong Yuan** **Zhejiang University of Technology**	*Session Keynote Speech* Micro/Nanostructured Material Generation from Silicon Waste-toward Material Resource Sustainability in Ultraprecision Machining **Jiwang Yan** **Keio University**	*Session Keynote Speech* Surface Integrity of Ti_6Al_4V Subjected to High-speed Grinding **Bi Zhang** **Southern University of Science and Technology**
08:55-09:15	*Invited Talk* Research on Double-sided Lapping of Thin Copper Plate with Weak Rigidity **Jiang Guo** **Dalian University of Technology**	*Invited Talk* Surface Reaction Kinetics for Selective Atomic Layer Deposition **Rong Chen** **Huazhong University of Science and Technology**	*Invited Talk* Acceleration Feedback Control in Fast Tool Servo Freeform Machining **Xichun Luo** **University of Strathclyde**
09:15-09:30	Tool-wear-free Electrochemical Discharge Machining via Electrolyte Jet (046) **Yonghua Zhao* and Jiajun Lu** **Southern University of Science and Technology**	Exploring Pulsed Laser Modification and Ablation at Close-to-atomic Scale (145) **Haojie An, Jinshi Wang and Fengzhou Fang*** **Tianjin University**	Experimental Study of Electrochemical-assisted Drilling of Optical Glass (014) **Tianhao Cheng and Wei Han*** **Fudan University**
09:30-09:45	Polishing of Ti_6Al_4V Internal Structures Made by Laser-based Powder Bed Fusion (155) **Mingyue Shen and Fengzhou Fang*** **University of Dublin**	Atomic Observation of Structural Evolution of Turning Aluminum Surface during Ion Beam Bombardment (120) **Chunyang Du*, Tao Lai, Xiaoqiang Peng, Shanyong Chen and Cheng Huang** **National University of Defense Technology**	Electrochemical Mechanical Polishing of 4H-SiC by Polishing Pads with Through Holes (186) **Yang Zhao, Renke Kang, Yuewen Sun and Zhigang Dong*** **Dalian University of Technology**
09:45-10:00	Increasing Removal Efficiency of Electrical Discharge Machining Using LC Pulse Generator (083) **Masanori Kunieda* and Lin Jiang** **The University of Tokyo**	Large-area Fabrication of Micro-grooves on Ferrous Metals by Ultrasonic Vibration-Assisted Turning with Laser-modified cBN Tools (045) **Lin Zhang, Daichi Kitagawa, Tushar Meshram and Jiwang Yan*** **Changchun University of Technology**	Machinability Improvement in Micro Milling AlN after Laser Chemical Milling (157) **Jiawei Liu, Ni Chen*, Yibo Jiang, Junyi Zhao and Ning He** **University of Aeronautics & Astronautics**
10:00-10:15	A Study on Tool Influence Function and Polished Surface Characteristics of Belt Polishing Spinel ($MgAl_2O_4$) (065) **Jianbo Zhao, Sheng Wang* and Qingliang Zhao** **Harbin Institute of Technology**	Micro Grooving of PZT by Femtosecond Pulsed Laser Irradiation (091) **Rei Aoba, Yuka Yamamuro, Masashi Hiraoka, Takashi Hitomi and Jiwang Yan*** **Keio University**	The Direct Measurement of Cutting Temperature in Micro Zone Using a Boron-doped Diamond Tool (167) **Shiquan Liu, Liang An and Yuan-Liu Chen*** **Zhejiang University**
10:15-10:30	Generation of Silicon Nanoparticles by Line-focused Laser Irradiation on Waste Silicon Powders (012) **Daiki Nakano and Jiwang Yan*** **Keio University**	A Microfluidic Step-emulsification Device with Nozzles Arrayed on a Slit (084) **Chunqi Zheng, Shuzo Masui, Yusuke Kanno and Takasi Nisisako*** **Tokyo Institute of Technology**	Fabrication of Functional Surface Using Water Jet Guided Laser Processing: Mechanism of Surface Structure Fabrication by Underwater Processing of the Workpiece (032) **Mayuko Osawa, Shoichi Ui, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi*** **The University of Tokyo**
10:30-10:45	Tea/coffee Break		
	Micro/Nano Fabrication Processes (II)	• Metrology (I) • IoT/AI/Big Data in Manufacturing	Manufacturing Systems and Machine Tools
Session Chair	Zhigang Dong, Dalian University of Technology Chaoyang Wei, Shanhai Institute of Optics and Fine Mechanics	Yanlong Cao, Zhejiang University Zhishan Gao, Nanjing University of Science and Technology	Yongsheng Gao, The Hong Kong University of Science and Technology Zhanwen Sun, Guangdong University of Technology
10:45-11:10	*Session Keynote Speech* Photoelectrochemical Mechanical Polishing (PECMP) Theory and Technology for GaN Substrates **Zhigang Dong** **Dalian University of Technology**	*Session Keynote Speech* Comb-based Optical Frequency Synthesizer for Precision Metrology with 15-digit Accuracy **Seung-Woo Kim** **Korea Advanced Institute of Science and Technology**	*Session Keynote Speech* In-process Form Profile Optical Measurement under Coolant Condition **Yongsheng Gao** **The Hong Kong University of Science and Technology**
11:10-11:30	*Invited Talk* Laser-based Process for Fabricating High Laser Damage Threshold Optics **Chaoyang Wei** **Shanghai Institute of Optics and Fine Mechanics**	*Invited Talk* Metrology of Microstructure Tomography by Interferometric Microscopy **Zhishan Gao** **Nanjing University of Science and Technology**	*Invited Talk* A Cooperative Rotary Servo Indenting Technology for Flexible Machining Micro-Structured Surfaces **Zhanwen Sun** **Guangdong University of Technology**
11:30-11:45	High-speed Observation of Cathode Phenomena in Electrical Discharge Machining (085) **Qi Li, Xiaodong Yang* and Masanori Kunieda** **Harbin Institute of Technology**	*Invited Talk* In-process Measurement for Micro and Nano-scale Diamond Cutting **Yuanliu Chen** **Zhejiang University**	Thermal Error Estimation of Machine Tools by Data-fit Models Based on Multi-point Temperature Sensor (098) **Shun Tanaka*, Toru Kizaki, Yuta Teshima, Kenichi Tomita and Naohiko Sugita** **The University of Tokyo**

11:45:12:00	Prediction Model for Depth of Grain Refinement Layers on the Machined Surface of Carbon Steel Based on Dynamic Recrystallization (141) **Shuyao Liu, Xibin Wang, Zhibing Liu*, Hongtao Chen and Pai Wang** **Beijing Institute of Technology**	A Novel Single-microparticle Total Analysis System Driven by Optical Tweezers (029) **Ryohei Omine, Yushen Liu, Shuzo Masui, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi*** **The University of Tokyo**	Visualization Experiment of Immersion Cooling for Battery Thermal Management System Using Mineral Oil and Aluminum Nitride Nanofluids (082) **Ya-Chi Ho*, Po-Chih Chen, En-Lan Hu, Tsai-Liang Wu, Cheng-Hsuan Lin and Da-Jeng Yao** **National Tsing Hua University**
12:00-12:15	Investigation of Plasma Gas for Modifying Gallium Nitride in Plasma-assisted Polishing (069) **Yuya Ohnishi, Tong Tao, Rongyan Sun*, Yuji Ohkubo and Kazuya Yamamura** **Osaka University**	Image Treatment of Spatter Flight Phenomena for Porous Metallic Parts Using Powder Bed fusion (059) **Justin Lach*, Moju Zhao, Ryo Okawara, Hiroshi Yoshizaki, Masahiko Sairaiji, Masayuki Nakao and Keisuke Nagato** **The University of Tokyo**	Effect of Surface Processing of Co-28Cr-6Mo Alloy on Wear Behaviour of Ultra-high Molecular Weight Polyethylene in Artificial joint (015) **Yoshitaka Nakanishi*, Yukio Fujiwara and Yoshihiro Komohara** **Kumamoto University**
12:15-12:30	Experimental Study on the Effects of Vibration Behavior on SQUD (043) **Takaaki Yoshimura, Tomohisa Tanaka** **Tokyo Institute of Technology**	Reducing Battery Temperature and Short Circuit Risk With AI-optimized Nanofluids-mineral Oil Immersion Cooling (021) **Guan-Jhih Wu, Ya-Chi Ho, Yung-Jen Cheng, Tsai-Liang Wu and Chih-Ya Shen*** **National Tsing Hua University**	A New Geometric-error Synthesis Model Based on The Abbe Principle of a Three-axis Machine Tool (024) **Tao Lai, Xiaoqiang Peng*, Chaoliang Guan, Chunyang Du, Shanyong Chen and Chen Huang** **National University of Defense Technology**
12:30-12:45	Effect of Ultra-precision Grinding of Sapphire on Polishing Performance (062) **Sheng Wang* and Qingliang Zhao** **Harbin Institute of Technology**	Improvement of the Transient Levitation Response of a Magnetic Levitation System Using Hybrid Fuzzy and Artificial Neural Network Control (102) **Yupeng Zheng and Hyeong-Joon Ahn*** **Soongsil University**	Temperature Dependency of Stiffness in Machine Tool Spindle Using Carbon Fiber Composite (092) **Daisuke Kono* and Yuki Nara** **Kyoto University**
12:45-13:45	Lunch Break (13:00-14:00, Venue: Hotel ICON 1/F)		
	Room 1	**Room 2**	**Room 3**
	Micro/Nano Fabrication Processes (III)	• Bio/ Optical/ Medical Manufacturing and Applications (I) • Automation, Mechatronics, and Robotics	Additive Manufacturing (I)
Session Chair	Masanori Kunieda, The University of Tokyo Yasuhisa Sano, Osaka University	Xuejun Zhang, Changchun Institute of Optics Fine Mechanics and Physics, Chinese Academy of Science Anthony Beaucamp, Keio University	Hideki Aoyama, Keio University Xiewen Wen, The Hong Kong Polytechnic University
13:45-14:10	*Session Keynote Speech* Challenges In Electrochemical Machining **Masanori Kunieda** **The University of Tokyo**	*Session Keynote Speech* Evolution of Space Optical Systems: ----From Aspheres to Freeforms **Xuejun Zhang** **Changchun Institute of Optics Fine Mechanics and Physics, Chinese Academy of Science**	*Session Keynote Speech* Fully Automated Additive Manufacturing Using Directed Energy Deposition (DED) **Hideki Aoyama** **Keio University**
14:10-14:30	*Invited Talk* Surface Finishing of X-Ray Crystal Optical Elements by PCVM (Plasma Chemical Vaporization Machining) **Yasuhisa Sano** **Osaka University**	*Invited Talk* Automated Design and Fabrication of Freeform Micro-lens-arrays **Anthony Beaucamp** **Keio University**	Feature Value Detection from High-speed Observation of Spatter for Prediction of Porosity in Metals Formed Using Powder Bed Fusion (036) **Ryo Okawara*, Moju Zhao, Justin Lach, Hiroshi Yoshizaki, Masahiko Sairaiji, Masayuki Nakao and Keisuke Nagato** **The University of Tokyo**
14:30-14:45	Predicted of Grinding Forces in Ultrasonic Vibration Grinding of Fused Silica Glass Based on The Stochastic Distributed Abrasive Grits (026) **Cheng Huang*, Chunyang Du, Tao Lai, Shanyong Chen, Xiaoqiang Peng and Ming Zhou** **National University of Defense Technology**	Characterization of Damage Properties of Ultra-precision Machined KDP Crystals Under Intense Laser Irradiation (149) **Wenyu Ding, Linjie Zhao, Jian Cheng, Zhaoyang Yin, Qi Liu, Guang Chen, Hongqin Lei and Mingjun Chen *** **Harbin Institute of Technology**	Evaluating Particle Separation in A 3D-printed Deterministic Lateral Displacement Device (096) **Yeyi Tang, Guangchong Ji, Yusuke Kanno and Takasi Nisisako*** **Tokyo Institute of Technology**
14:45-15:00	Simulation of Wire Electrode Temperature in Wire Electrical Discharge Machining Based on Temperature Measurement Results by Two-color Pyrometer with Optical Fiber (095) **Toshiki Hinata, Tomohiro Koyano*, Tatsuaki Furumoto, Yohei Hashimoto and Mitsugu Yamaguchi** **Kanazawa University**	Bacteria-assisted Production System for Functional Nano- and Microstructures Made with Programmable Viruses (005) **Hayato Goto, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi*** **The University of Tokyo**	Effect of Laser Conditions on Surface Morphology after Powder Bed Fusion (078) **Liwei Chen*, Masayuki Nakao and Keisuke Nagato** **The University of Tokyo**
15:00-15:15	Bottom Cutting High-speed EDM Using Thin Plate Electrode (033) **Keisuke Takeuchi and Hideki Takezawa*** **Kogakuin University**	Small Multi-legged Robots for Moving on Wall Surfaces and its Evaluation System for Adsorption Mechanism with Negative Pressure (004) **Mitsutoshi Watanabe, Masato Mizukami*, Naohiko Hanajima and Yoshinori Fujihira** **Muroran Institute of Technology**	Design of Chamber for Selective Laser Melting Based on Inert-gas Flow Simulation (110) **Yuki Fujiwara, Ryo Koike*, Yasuhiro Kakinuma, Keiichi Yamazaki, Takanori Mori and Yoko Hirono** **Keio University**
15:15-15:30	Numerical Investigation on Ultrasonic Assisted Multi-abrasive Scratching of Silicon Carbide (151) **Zhongwang Wang, Renke Kang, Yan Bao, Yidan Wang, Yan Qin, Jiansong Sun and Zhigang Dong*** **Dalian University of Technology**	Pose Estimation of a Mobile Robot for Accurate Object Detection using Digital Twin and Bayesian Optimization (080) **Su-Young Park, Doyoun Kim, Seouhwon Yi and Sung-Hoon Ahn*** **Seoul National University**	Elucidation of Spatter Formation Mechanism with High-speed Observation of Melt Pool in Metal Powder Bed Fusion (049) **Hiroaki Suzuki*, Moju Zhao, Yusuke Ito, Takumi Koike, Masayuki Nakao and Keisuke Nagato** **The University of Tokyo**

15:30-15:45	An Approach towards an Integrated Process Control for Vibropeening (Virtual) (148) **Abhay Gopinath and A. Senthil Kumar*** **National University of Singapore**	A Piezoelectric Stick-slip Manipulator for A Holonomic Precision Mobile Robot (094) **Ryosuke Kinoshita, Eiji Kusui, Hazumu Kusama, Yohei Tsukui, Rintaro Minegishi, Yuna Sugiyama, Yuta Sunohara, Chihiro Sekine and Ohmi Fuchiwaki*** **Yokohama National University**	Ambient Vibration Conductance of FDM-Printed PLA Components (Virtual) (139) **Vinodth Paniselvam* and A. Senthil Kumar** **National University of Singapore**
15:45-16:00	New Insights into Stray Corrosion Suppression in Electrochemical Jet Machining (050) **Bangyan Dong, Weidong Liu and Yonghua Zhao*** **Southern University of Science and Technology**	Lightweight Design Methods for Water Strider Micro-robot Using Artificial Intelligence (129) **Sora Komine, Daigo Misaki* and Kenji Suzuki** **Kogakuin University**	Analysis of the Relationship Between Process Parameters and Hardness for the Finishing Process by Wire Arc Additive Manufacturing Combined with the FSB Tool of Austenitic Stainless Steel 316L (153) **Teerayut Cordkaew*, Jun`Ichi Kaneko and Takeyuki Abe** **Saitama University**
16:00-16:15	Tea/coffee Break		
	Micro/Nano Fabrication Processes (IV)	Metrology (II)	Molding and Forming Technology
Session Chair	Jianfeng Xu, Huazhong University of Science and Technology Jianjian Wang, Tsinghua University	Seung-Woo Kim, Korea Advanced Institute of Science and Technology Liang-Chia Chen, National Taiwan University	Zejia Zhao, Shenzhen University Lihua Li, Shenzhen Technology University
16:15-16:40	*Session Keynote Speech* In-situ Field Assisted Ultra-precision Machining: Theory, Technology and Equipment **Jianfeng Xu** **Huazhong University of Science and Technology**	*Session Keynote Speech* Advancements in Optical Metrology for Next-generation Semiconductor Packaging **Liang-Chia Chen** **National Taiwan University**	*Session Keynote Speech* Non-Isothermal Hot Embossing of High Melting Point Glass Lens **Lihua Li** **Shenzhen Technology University**
16:40-17:00	*Invited Talk* Ultrasonic Micro/Nano Manufacturing **Jianjian Wang** **Tsinghua University**	*Session Keynote Speech* Accurate and Traceable Reference Nano Dimensional Metrology (Virtual) **Gaoliang Dai** **Physikalisch-Technische Bundesanstalt**	*Invited Talk* Gravity-assisted Hot Embossing for Producing High-quality Glass Micro/nanostructures **Feng Gong** **Shenzhen University**
17:00-17:15	Femtosecond Laser Direct Writing Based Laser-Induced Graphene (LIG) Formation on Woods for Smart Home Realization (086) **Han Ku Nam, Dongwook Yang, Tongmei Jing, Younggeun Lee, Young-Ryeul Kim, Truong-Son Dinh Le, Seung-Woo Kim and Young-Jin Kim *** **Korea Advanced Institute of Science and Technology (KAIST)**	Development of X-Ray Fourier Ptychography Using a Mirror-Based Achromatic X-Ray Microscope (066) **Toshiki Ito*, Takato Inoue, Shinnosuke Kurimoto, Yuto Tanaka, Yoshiki Kohmura, Makina Yabashi and Satoshi Matsuyama** **Nagoya University**	Heating Process Effects before Hot Water Treatment in Injection Molding Direct Joining (099) **Shuohan Wang*, Zhongqi Cui, Fuminobu Kimura and Yusuke Kajihara** **The University of Tokyo**
17:15-17:30	High-precision Acoustic Cell Sorting in BioMEMS (130) **Ye Ai*** **Singapore University of Technology and Design**	Gas-cell Locked Frequency Sweeping Interferometry Achieving High-speed Absolute Displacement Measurement (079) **Hsi-Hui Lin, Chen-Yu Liao and Liang-Chia Chen*** **National Taiwan University**	Development of Automatic Mold Repair System Using Directed Energy Deposition - Automatic Detection of Cracks on Mold- (119) **Kazuki Abe*, Ryo Koike and Hideki Aoyama** **Keio University**
17:30-17:45	Multiphysics Simulation of Micro Electrochemical Machining Including Circuit Analysis of Pulse Power Supply (115) **Tomohiro Koyano* and Tatsuaki Furumoto** **Kanazawa University**	Robust Surface Imaging Method based on Quantum Single Pixel Imaging (076) **Elie Magnon*** **Osaka University**	Investigation on Fog Defect of Molded Glass Lens (154) **Guangyu Liu and Fengzhou Fang*** **Tianjin University**
17:45-18:00	Development of Deep Etching Method by Atmospheric Pressure Plasma Jet (008) **Kenta Nakazawa* and Futoshi Iwata** **Shizuoka University**	Design of Gaze Estimation Model Based on Multiple Feature Fusion (138) **Zhonghe Ren, Fengzhou Fang* and Rui Niu** **Tianjin University**	Automatic Tuning of a Hyperparameter for Autonomous Parameter Exploration in Roll-to-roll Heating System (093) **Masaki Ito*, Ura Tessho, Kohei Nagai, Toru Takahashi, Kentaro Iribe, Masayuki Nakao and Keisuke Nagato** **The University of Tokyo**
18:00-18:15	Research on Surface Integrity Evolution of Short Arc Assisted Milling of Superalloys (158) **Pai Wang, Yifan Bai, Wenxiang Zhao, Hongtao Chen, Zhibing Liu, Shuyao Liu** **Beijing Institute of Technology**	Automated Detection of Mediterranean Snail in Australia Agricultural Fields using Machine Vision (132) **Shi Zhao and Tien-Fu Lu*** **The University of Adelaide**	
18:30	Banquet Venue: Victoria Harbour Supreme 9/F, 1 Peking Road, Tsim Sha Tsui		

*Corresponding Author

24 November 2023 Detailed schedule

Time	Event		
	Room 1		
Session Chair	Session Chair: Hideki Aoyama, Keio University		
08:30-09:10	Ultimate Condensation of X-Ray Free Electron Laser Down to Single Nanometer Size by Precision Mirror Devices ***Kazuto Yamauchi*** ***Osaka University***		
	Room 1	**Room 2**	**Room 3**
	Non-traditional Machining (I)	Metrology (III)	High Speed and Precision Machining (II)
Session Chair	Kui Liu, Singapore Institute of Manufacturing Technology (SIMTech) Quanli Zhang, Nanjing University of Aeronautics and Astronautics	Shuming Yang, Xi'an Jiaotong University Mingjun Ren, Shanghai Jiao Tong University	Jiwang Yan, Keio University Xusheng Yang, The Hong Kong Polytechnic University
09:15-09:40	*Session Keynote Speech* Recent Development of Ultra-precision Machining for Optical Applications **Kui Liu** **Singapore Institute of Manufacturing Technology**	*Session Keynote Speech* Micro/nano Measurement Technology and the Application in IC **Shuming Yang** **Xi'an Jiaotong University**	*Session Keynote Speech* High Volume Replication of Micro and Nanoscale Optical Surface Structures (Virtual) **Allen Yi** **The Ohio State University**
09:40-10:00	*Invited Talk* Grits Texturing and Grinding Performance of Brazed Diamond Wheel **Quanli Zhang** **Nanjing University of Aeronautics and Astronautics**	Development of Ultra-high Groove-density Grating by Ultrarapid Electron Beam Lithography for Full-field X-ray Spectromicroscopy (052) **Kyota Yoshinaga*, Yoko Takeo, Noboru Furuya, Kai Sakurai, Jordan T. O'neal, Satoru Egawa and Takashi Kimura** **The University of Tokyo**	Bi-telecentric Phase Measurement Deflectometry for Optical Elements Quality Control (144) **Yingmo Wang and Fengzhou Fang*** **Tianjin University**
10:00-10:15	Parameters Optimization for Low Residual Strain and High Manufacturing Speed for Polypropylene Material during Laser Drilling (168) **Shih-Hao Lin, Chung-Wei Ku, Cheng-Lun Kan, Han-San Xie, Chao-Ching Ho and Ching-Yuan Chang** **National Taipei University of Technology**	Deep Groove Measurement using Broadband Optical Frequency Comb Scattering Spectroscopy (025) **Satoshi Itakura*, Tsutomu Ueohara, Yasuhiro Mizutani and Yasuhiro Takaya** **Osaka University**	Vibrational Monitoring and Analysis of Tool Wear Mechanism in High-speed Micro-grinding (042) **Yifu Liao*, Jiahui Liu, Toru Kizaki, Keisuke Nagato, Masayuki Nakao and Naohiko Sugita** **The University of Tokyo**
10:15-10:30	High Precision Grinding of Large-aperture Aspherical Surface Based on Medium-Low Frequency Error Suppression Method (088) **Guoyan Sun, Xiabin Ji*, Jiaoteng Ding, Hang Cheng and Jigong Zhang** **Xi'an Institute of Optics and Precision Mechanics, Chinese Academy of Science**	Enhanced Measurement Technique for Lens Centering Error with Power Analysis and Subwavelength Grating-patterned Prism Module (111) **Yu-Zhen Mao, Chin-Ting Ho, Shiau-Cheng Shiu and Chun-Wei Liu*** **National Tsing Hua University**	Ultra-precision Machining Of 95W-3.5Ni-1.5Fe Alloy by Ultrasonic Elliptical Vibratory Turning (152) **Hao Wang, Xiaoguang Guo, Shang Gao, Xianglong Zhu, Guolin Yang and Yan Bao*** **Dalian University of Technology**
10:30-10:45	Study On Machining Quality of Aluminum Honeycomb in Ultrasonic Cutting by Straight-blade Knife (188) **Jiansong Sun, Mingyue Wang, Wei Xing, Pengfei Zhang, Zhiyao Li and Yidan Wang*** **Dalian University of Technology**	Performance Evaluation of On-machine Measurement Software (030) **Hibiki Tsubota, Ryosuke Kaji and Yukitoshi Lhara*** **Osaka Institute of Technology**	Fabrication of the Aspherical Mold Inserts by the Laser-assisted Turning (160) **Hanheng Du and Suet To*** **The Hong Kong Polytechnic University**
10:45-11:00	An Investigation on The Effects of Feature Size in High-frequency Ultrasonic Vibration-assisted Sculpturing of Microlens Array (137) **Canbin Zhang, Chi Fai Cheung*, Xiaoliang Liang and Benjamin Bulla** **The Hong Kong Polytechnic University**	A Broadband Spectrometer with Enhanced Spectral Resolution using an Off-axis Elliptical Zone Plate (104) **Hyeokin Kang, Quang Huy Vu, Younggeun Lee, Young-Jin Kim and Joohyung Lee*** **Seoul National University of Science and Technology**	Numerical And Experimental Investigation of the Form Maintainability of Structured Array Surfaces in Maskless Fluid Jet Polishing (071) **Zili Zhang, Chi Fai Cheung, Chunjin Wang* and Jiang Guo** **The Hong Kong Polytechnic University**
11:00-11:15	Tea/coffee Break		
	Non-traditional Machining (II)	Metrology (IV)	Additive Manufacturing (II)
Session Chair	Yung-Kang Shen, Taipei Medical University Hui Deng, Southern University of Science and Technology	Shanyong Chen, National University of Defense Technology Da Li, Nankai University	Shih-Chi Chen, The Chinese University of Hong Kong Zibin Chen, The Hong Kong Polytechnic University
11:15-11:40	*Session Keynote Speech* Surface Modification of Biomedical Metals by Femtosecond Laser **Yung-Kang Shen** **Taipei Medical University**	*Session Keynote Speech* Interferometric Testing and Alignment of Multiple Optical Surfaces Based on CGHs **Shanyong Chen** **National University of Defense Technology**	*Session Keynote Speech* Digital Holography-based Micro-additive Manufacturing **Shih-Chi Chen** **The Chinese University of Hong Kong**
11:40-12:00	*Invited Talk* Highly Efficient Figuring of X-Ray Mirrors Using a Jet Type Atmosphere Plasma **Hui Deng** **Southern University of Science and Technology**	Development of Composite Markers for High-precision Industrial 3D Inspection Systems (070) **Haochen Huang* and Daisuke Kono** **Kyoto University**	Multi-objective Bayesian Optimization Method for High Strength and Dimensional Accuracy in Thermoplastic Extrusion Additive Manufacturing (041) **Hiroto Ikeda*, Kota Aono, Masaki Ito, Masayuki Nakao and Keisuke Nagato** **The University of Tokyo**
12:00-12:15	Fundamental Study on CO_2 Laser Forming of Carbon Fiber Reinforced Thermoplastic Sheet-relationship between Pulse Waveform and Forming Characteristics (064) **Ryoji Kitada*, Sena Kizaki, Yasuhiro Okamoto and Akira Okada** **Sojo University**	Surface Profile Error Evaluation Method of Machined Honeycomb Cores (185) **Yan Qin, Renke Kang, Wei Xing, Mingyue Wang, Pengfei Zhang, Zhiyao Li and Zhigang Dong*** **Dalian University of Technology**	Hybrid Finishing of The Additively Manufactured Tubular Lattice Structure for Medical Application (081) **Jiong Zhang, Ruochen Hong, Qianqian Nie and Hao Wang*** **National University of Singapore**

12:15-12:30	Corrosion-resistant Coating Based on a Composite of Graphene Oxide and Flaky Zinc-rich Epoxy (002) **Tzu-Yu Huang, Po-Hung Cheng, Wei-Hsuan Hsu and Hung-Yin Tsai*** **National Tsing Hua University**	Broadband Spectrum Generation Using IR-laser Pumped Laser-sustained Plasma (106) **Canh Doan and Joohyung Lee*** **Seoul National University of Science and Technology**	Research on Mesoscale Modeling and Simulation of Selective Laser Melting Process of Quartz Powder (010) **Yating Qiu, Tian Yang and Wei Han*** **Fudan University**
12:30-12:45	A Hyper-viscoelastic Continuum Model for Preforming and Consolidation of Woven Carbon Fabric Reinforced Polymers (CFRPs) (126) **Deyong Sun and Weizhao Zhang*** **The Chinese University of Hong Kong**	Enhancing the Accuracy of Ultra-precision Straightness On-machine Measurements Based on Uncertainty Propagation Law (192) **Pu Huang, Jin Xie, Zhiguang Liu, Zhilin He, Xuancheng Huang and Shengyu Shi*** **South China University of Technology**	Investigation of Surface Roughness Effect on Machining Process of Workpieces Deposited by Wire and Arc Additive Manufacturing Method (103) **Gustavo Quadra Vieira Dos Santos*, Jun`Ichi Kaneko and Takeyuki Abe** **Saitama University**
12:45-13:00	Piezo Flexure Mechanism for Extending Pulse Repetition Rate Control Range (116) **Woojeong Lee, Jungyoon Kim, Joohyung Lee*, Seongheum Han, Seungman Kim and Jeongseok Oh** **Seoul National University of Science and Technology**	Interferometric Profiling of Wafer Surface Using Deep Learning and Two-frame Interferometry (063) **Jurim Jeon, Yangjin Kim* and Naohiko Sugita** **Pusan National University**	Improvement of Young's Modulus of the Structures Fabricated by Laser-assisted Electrophoretic Deposition (006) **Yuki Yoshimoto, Kenta Nakazawa, Makoto Ishikawa and Futoshi Iwata*** **Shizuoka University**
13:00-14:00	Lunch Break (13:00-14:00, Venue: Hotel ICON 1/F)		
	Non-traditional Machining (III)	Metrology (V)	Bio / Optical/ Medical Manufacturing and Applications (II)
Session Chair	Huapan Xiao, The Hong Kong Polytechnic University Guijun Mitch Li, The Hong Kong University of Science and Technology	Chunjin Wang, The Hong Kong Polytechnic University	James Kit Hon Tsoi, The University of Hong Kong Wai Sze Yip, The Hong Kong Polytechnic University
14:00-14:25	*Session Keynote Speech* Advancing Towards the Fabrication and Implementation of Freeform Optics **Xiaodong Zhang (Virtual)** **Tianjin University**	XYθ Displacement Sensor by Four Encoders for Wide and Precise Measuring of Holonomic Robot (122) **Ohmi Fuchiwaki, Masato Shiota, Eiji Kusui, Yohei Tsukui, Chihiro Sekine, Ryosuke Kinoshita** **Yokohama National Unversity**	*Session Keynote Speech* Freeform Phase Plate in Filament-induced fluorescence spectroscopy (FIFS) System **Xing Zhao (Virtual)** **Nankai University**
14:25-14:45	*Invited Talk* Advanced Laser Manufacturing for Interdisciplinary Applications **Guijun Mitch Li** **The Hong Kong University of Science and Technology**	A PSF-model-based CNN Approach to Enhancing Microscopic Image Resolution (109) **Yu-Ting Cheng, Wei-Yun Lee and Liang-Chia Chen** **National Taiwan University**	*Invited Talk* Surface Treatment Methods for Dental Zirconia **James Kit Hon Tsoi** **The University of Hong Kong**
14:45-15:00	Fabrication of Carbon Nanotube Field Emission Tip Array Based on Laser Processing and Research on the Characteristics of Field Emission Array (007) **Wei-Che Lin, Kao-Jen Lin and Hung-Yin Tsai** **National Tsing Hua University**	Film Thickness Measurement by Ultrasonic Atomic Force Microscope (165) **Mingyu Duan, Chengjian Wu and Yuan-Liu Chen** **Zhejiang University**	Development of a Novel Deformable X-Ray Mirror Based on a Single-crystal Piezoelectric Elements (067) **Junya Yoshimizu, Takato Inoue, Maaya Kano, Sota Nakabayashi, Yoshiki Kohmura, Makina Yabashi, Satoshi Matsuyama** **Nagoya University**
15:00-15:15	Laser-assisted Nanoimprint on Glass Materials and Its Mechanism (068) **Takehiro Mitsuda, Keisuke Nagato and Masayuki Nakao** **The University of Tokyo**	Investigation of Optimal Conditions in Cube Machining Test on Five-axis Machining Center (031) **Tomohiro Sawada, Sota Kawakami and Yukitoshi Ihara*** **Osaka Institute of Technology**	Separating Glass Sheets via Mechanically, Selectively Induced Median Cracks (097) **Sho Itoh, Souta Matsusaka, Hirofumi Hidai, Kumiko Murakami and Mitsuru Kitaichi** **Chiba University**
15:15-15:30	Ultra-short Time Meniscus-confined Electrodeposition at Nanoscale (166) **Yutao Wang and Yuan-Liu Chen*** **Zhejiang University**	*Invited Talk* Digital Lensless Holographic Microscopy for Optical Metrology (Virtual) **Liangcai Cao** **Tsinghua University**	Si/SiC Ceramic Gradient Lattice Part Fabricated by Laser Powder Bed Fusion and Liquid Silicon Infiltration (142) **Ce Sun** **Wuhan University of Technology**
15:30-15:45	Micro-transfer-printing of Au Thin-film with Atomic Diffusion Bonding: Effects of Air-exposure Time and Stamp Modulus (028) **Naoyuki Tomura*, Weigang Kong, Tatsuki Sugihara, Takahiro Kono and Arata Kaneko** **Tokyo Metropolitan University**	Evaluation of Fine Feed Table Positioning for Non-contact Support Based on The Squeezed-air Effect (Virtual) (034) **Yuma Tamaru*, Tomohiro Ushijima and Hiroki Shimizu** **Kyushu Institute of Technology**	The Effect of Surface Roughness on the Sealing Performance of Mechanical Joints with Liquid Gaskets (060) **Akira Kakuta*, Yuki Saikachi and Yuto Masujima** **National Institute of Technology, Tokyo College**
15:45-16:00	Effect Of Crystal Orientation on Micro-cutting Mechanisms of FCC Crystal: Crystal Plasticity Finite Element Simulation (125) **Zhenting Zhang*, Hao Wang, Wenhan Zeng and Jane Jiang** **National University of Singapore**		Optical Design and Analysis of Micro-grooves Machined by Ultra-precision Machining (193) **Cheung Tong Cheng, Suet To*** **The Hong Kong Polytechnic University**
16:00-17:30	**Technical visit II (Venue: The Hong Kong Polytechnic University)** *Please register at the reception desk (Max. 80 people, on a first come, first served basis)*		

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Note:

Plenary Keynote 40 min (35 min presentation + 5 min Q&A)
Session Keynote 25 min (20 min presentation + 5 min Q&A)
Invited Talk 20 min (17 min presentation + 3 min Q&A)
Regular Talk 15 min (12 min presentation + 3 min Q&A)
Poster sessions: A0 Size, will be exhibited from 23-24 Nov.

Plenary Keynote Speeches

機械人三維智能數位眼

3D Smart-Eye for Robotics & Smart Manufacturing

plusD
Diversify Your Dimensionality
益維科技有限公司

背景 Company Background

益維科技有限公司專注于 3D 圖像傳感技術和視覺測量產品，爲智能製造機械人等不同領域提供專業的 3D 測量、檢測、定位、識別等解決方案和服務。我們的產品和定制化方案目前已經服務于內地不同領域的多家龍頭企業，助力其生產效率的提升和智慧化無人工廠的步伐。益維科技的使命是爲製造業及相關行業帶來革命性的變化，并致力打造智能自動化工業物聯網。

PlusD has specialized on 3D Imaging & Sensing Technologies and vision inspection systems with a diversify of applications. We provide customized solutions and professional services on 3D Measurement, Inspection, Positioning, Identification, etc. Our products and customized solutions are serving multiple leading enterprises for different fields in mainland China as well as enhancing their production efficiency and develop intelligent unmanned factories. The mission of PlusD is to bring revolutionary changes to smart IIoT.

解決方案及服務 Solutions & Services

- 機器人3D視覺傳感器系統，用于定位和控制/基于機器人視覺的校準服務
  Robotic 3D vision sensor system for positioning & controlling / Robotic vision-based calibration services
  - 消除傳統機器人控制的虛擬約束框架
    Remove virtual restrained frame of traditional robotic control
  - 高速獲取 3D 數字信息
    High-speed 3D digital information acquisition
- 爲智能製造定制的在綫三維智能測量系統/三維智能檢測解決方案
  Customized In-line 3D smart metrology system/ 3D smart measuring solution for manufacturers
  - 智能3D測量
    3D Smart measurement
  - 深度學習標準識別包
    Deep learning standard recognition package
  - 亞微米精度
    Submicron accuracy
  - 視覺特徵 AI 識別
    AI recognition of visual features
  - 在線高速測量
    In-line high-speed measuurement
  - 量身定造解決方案
    Customized solutions & services

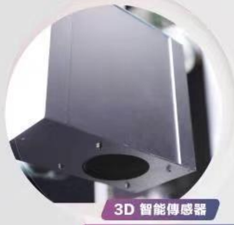
核心技術 Key Technologies

- 邊緣計算 Edge Computing
- AI 深度學習 AI Deep Learning
- 3D 影像處理技術 3D Image Processing Technologies
- 超精密加工和測量技術 Ultra-precision Machining & Measurement Technologies
- 自主研發數字 3D 傳感技術 Patented Digital 3D Sensing Technologies

產品 Products

2D智能工業相機
2D Smart Industrial Camera

3D超精密在綫測試設備
3D Ultra-precision On-Machine Measurement Equipment



3D 智能傳感器
3D Intelligent Sensor

技術優勢及產品亮點 Technical and Product Highlights

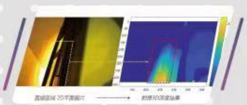
- 單鏡頭3D Single Lens 3D
- 單次拍照式測量 Single Snapshot Imaging
- 超高精准度 Ultra-precision
- 3D 表面形貌輸出 3D Digital Surface Profile
- 應用場合廣範 Wide Applications
- 拓展性强 Strong Extendibility
- 精控成本 Precise Cost Control
- 效率提升 Efficiency-boosted
- 多尺度測量 Multiscale Measurements

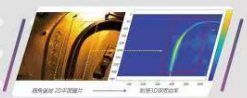
應用案例 User Cases

1. 三維智能視覺實時塗膠監測 Smart 3D Real-time Inspection System

定性判斷輸出：斷膠、歪倒、流動性過高、高度不够、表面形貌不滿足形狀要求等情況。

Qualitative inspection output : Discontinuous glue, crooked, low viscosity, insufficient thickness, substandard surface profile or section shape.





意義 Benefits

- 提升下綫合格率，降低返修率
  Increase off-line pass rate and lower returning rate
- 爲提高綫上合格率提供可靠的資料支撐
  Provide reliable data support to enhance compliance rate
- 結合設備過程資料，可實現設備的全生命周期管理及設備故障的預測
  Achieve full cycle equipment as well as equipment failure prediction forecast by utilizing equipment process data

2. 智能螺栓擰緊系統 Smart Screw Driving System

智能視覺識別：系統識別檢出率大於99.5%，可以精准找到不合格螺栓的位置，降低返修率。

Real-time Smart Visual Recognition : System identification detection rate is more than 99.5% so the location of unqualified bolts can be found accurately

意義 Benefits

- 螺栓擰緊實時監控
  Real-time Bolt-tightening Monitoring
- 防止錯擰、漏擰、重複擰
  Prevent false tightening, missing screws, repeated tightening
- 規範擰緊操作順序
  Standardize manipulation orders
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Damage-free Finishing of Optical Crystal Surfaces by Means of Plasma Modification

Fengzhou Fang
Laboratory of Micro/Nano Manufacturing Technology
Tianjin University

Biography

Professor Fengzhou Fang has been working in the fields of freeform optics design and manufacturing, bio-manufacturing, ultra-precision machining and metrology, and machine learning when he became a faculty member at university in 1982. He is the President of the International Academy of Production Engineering (CIRP), the former President of the International Academy of Engineering and Technology (AET) and the editor-in-chief of Nanomanufacturing and Metrology (NMME). Professor is also a fellow of CIRP, AET, the International Society for Nanomanufacturing (ISNM), and the Society of Manufacturing Engineers (SME).

Abstract

The atomic-level surface plays a crucial role in improving the damage threshold of optical crystals. The exploration of new finishing processes at the atomic and close-to-atomic scale (ACSM) is expected to lead to breakthroughs in device performance. Sesquioxide crystals are considered ideal for optical applications due to their low phonon energy, high thermal conductivity, high damage threshold, and high quantum efficiency. However, achieving an atomically smooth surface without subsurface damage is challenging due to the high hardness, brittleness, and low fracture toughness of sesquioxide laser crystals, limiting their applications. This plenary speech presents a novel process for atomic-level surface processing based on plasma-assisted etching (PaE). A comprehensive PaE system has been established to conduct investigations on finishing crystal surfaces. The exploration of high-performance machinery for atomic-level surface processing, along with the investigation of related technologies, can significantly contribute to the advancement of high-end manufacturing technology.

Digital Transformation of Machining Process

Dong Yoon Lee
Digital Transformation R&D Department
Korea Institute of Industrial Technology

Biography

He is a principal researcher at the Korea Institute of Industrial Technology. He received a Ph.D. degree in Mechanical Engineering from KAIST. His research topics include in-process monitoring/control through CNC communication and sensors, virtual machining, and process optimization. Currently, he is focused on developing and applying the digital thread for machining processes and a unified CNC communication platform. He is also actively involved in implementing a machine tending system.

Abstract

Currently, digital transformation has a significant impact on human lives. Digital transformation does not just mean a transformation of a (non-) physical element to a digitally identifiable one. It focuses on the utilization of digital technology for transforming and improving procedures or routines of business and operation. The manufacturing industry also recognizes digital transformation as a core competitive strategy and has been adopting the latest digital technology. This presentation delves into three crucial aspects of the digital transformation of the machining process: Data (D), Network (N), and Artificial Intelligence (A). As the generation and storage of data is much easier and cheaper, a large amount of digital data is being created. Data needs to be accurate and consistent, but every piece of manufacturing data, from model data [CAD] to inspection data [GD&T], should be cross-referenced to utilize the stored data and derive value from it. Firstly, the digital thread for the machining process will be addressed as an important aspect of data cross-referencing. A network is inevitable in digital transformation. Many devices and equipment are being connected to the internet, but communication among them is challenging due to the use of diverse protocols. The connection can be easily achieved, but the communication is not. Secondly, a unified CNC interface platform will be addressed as an important aspect of network exchangeability. There have been many trials in the application of AI in the manufacturing industry. Lastly, The AI application for process planning will be briefly addressed.

A Study on the Development of a Smart Manufacturing Framework

Senthil Kumar Anantharajan
Department of Mechanical Engineering
National University of Singapore

Biography

A. Senthil Kumar is an Associate Professor of Mechanical Engineering at the National University of Singapore. His expertise is in manufacturing with focus on Smart Manufacturing of micro/nano structures and fixture design. He has co-authored 2 books and has published over 250 technical papers in International Journals and conferences. He serves in the editorial board of the Journal of Manufacturing Processes, USA, Journal of Micro Manufacturing, Journal of Nanotechnology and Precision Engineering, Journals of Machines and Journal of Materials. He received several awards including the Outstanding Young Manufacturing Engineering Award, SME, USA and IES Prestigious Engineering Achievement Award from the Institute of Engineers, Singapore. He is a Fellow of ASME and ISNM. He has five patents to his credit and has licensed the technology to start a spin-off company which specializes in the manufacturing of ultra-precision machine tools.

Abstract

Micro milling is a manufacturing technique that is used for producing miniature features with intricate geometries. This has gained significant importance in various industries, including aerospace, electronics, and medical devices. To enhance the efficiency, accuracy, and overall productivity of micro milling operations, the tool geometry must be monitored and hence the development of a Digital Twin Framework to monitor the performance of the machine tool has become imperative. This research presents the design and implementation of a comprehensive Digital Twin Framework tailored specifically for micro milling processes. The framework encompasses a multi-faceted approach, combining advanced simulation, real-time data acquisition, and machine learning techniques. In addition, a discussion on how a smart incremental sheet metal forming is developed will be discussed. Finally, a discussion on the future of manufacturing, envisioning a world where digital twins and the metaverse converge will be provided.

Fabrication and Field Emission Characteristic of Carbon-based Nano Composite Materials

Hung-Yin Tsai
Department of Power Mechanical Engineering
National Tsing Hua University

Biography

Professor Hung-Yin Tsai is a Chair Professor and Dean of the College of Engineering at National Tsing Hua University in Taiwan. He received his Ph.D. in power mechanical engineering from National Tsing Hua University in 1999. His research interests include nano/microstructure fabrication and opto-electromechanical technology, advanced material and precision manufacturing technology, image processing, artificial intelligence and intelligent manufacturing, patent analysis, and creativity. In addition, he has published more than 100 journal articles, 150 conference papers, and 60 granted or pending patents in the above-mentioned areas.

Abstract

The field emission theory was proposed by Fowler and Nordheim. It states that when the material is applied an electric field, the barrier at the surface of an electron conductor becomes rounded triangular, and individual electrons can escape from the material in various circumstances. In recent years, a lot of field emission studies used carbon nanotubes (CNTs), graphene, diamond and other carbon materials as cathodes. Although CNTs have good field emission effect, the lifespan of the CNTs and the screening effect limits its applications.

In this presentation, the screening effects by different patterned carbon-based structures are introduced. A special diamond structure can slightly lower the screening effect. In addition, different kinds of carbon-based structures developed in Prof. Tsai’s lab, such as micro-crystal diamond/CNTs double-layered pyramid arrays, bristling few-layer graphite/diamond, and carbon nano-flake ball/CNT hybrid material, will be discussed.

From Precision to ‘Precisions’ – A Research Journey and the Lessons Learned

Tien-Fu Lu
School of Electrical and Mechanical Engineering
The University of Adelaide

Biography

Tien-Fu Lu received his Bachelor and MS of Science in Mechanical Engineering from National Cheng Kung University, Taiwan, followed by Ph.D. in Manufacturing and Mechanical Engineering from the University of south Australia, Australia, in 1997. He is currently a senior lecturer and the associate head of school – international and external engagement at the School of Electrical and Mechanical Engineering, University of Adelaide. He has been teaching courses including Robotics M, Electronics IIM, Mechatronics 1M, Sports Engineering I, and Sports Engineering II.

His research interests are mainly in the fields of Mechatronics and Robotics covering piezoelectric actuators/energy harvester, nano-positioning and measurement technologies, exoskeleton, flexure hinges, compliant mechanisms, chemical plume tracing using robots, operation modelling and optimisation. The applications are broad involving different industries including mining, agriculture, advanced manufacturing, space, and defence. He has been a Board member of ASPEN (Asia Society tor Precision Engineering and Nanotechnology since 2013, http://www.aspen-soc.org/#conferences. Besides, he has been contributing as members of various conference committees and chair/co-chair of sessions and editorial members of journals (editorial board member and co-editors). His career total citation is so far 2534 and the top cited paper has reached 405 citations.

As a chief investigator, he has been awarded grants in the past 5 years jointly with colleagues for more than 22 million dollars in total. He has published over 160 articles including book chapters, journal, and conference articles in the field of robotics and mechatronics. More details can be found at: https://researchers.adelaide.edu.au/profile/tien-fu.lu.

Abstract

This talk mainly presents some precision engineering research at the speaker’s Robotics Research Lab, School of Electrical and Mechanical Engineering, the University of Adelaide, South Australia accompanied by the lessons learned. The research to be covered includes nano-positioning using piezoelectric stack actuator and compliant mechanism, ‘precision’ robotics, ‘precision’ mining, ‘precision’ space technology, quantum enhanced ‘precision’ control, and ‘precision’ agriculture.

In addition to reporting the research, the ups and downs as well as the lessons learned will be shared. As every researcher is different, it is hoped that the lessons shared will remind and assist young researchers navigating their careers more successfully and satisfactorily, and the established researchers mentoring and cultivating the young researchers with more enjoyable life-long impacts.

Multiscale Manufacturing: From Structures to Functions

Zuankai Wang
Chair Professor of Nature-Inspired Engineering
Department of Mechanical Engineering
The Hong Kong Polytechnic University

Biography

Prof. Zuankai Wang is currently Chair Professor of Nature-Inspired Engineering in the Department of Mechanical Engineering at The Hong Kong Polytechnic University (PolyU) and concurrently serves as Associate Vice President (Research & Innovation). Professor Wang received his B.S. degree from Jilin University in 2000, M.S. degree from the Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, in 2003, and Ph.D. degree from Rensselaer Polytechnic Institute in 2008. After a one-year postdoctoral training at Columbia University, he joined the City University of Hong Kong (CityU) as Assistant Professor in 2009 and was promoted to Chair Professor in 2021. He was the Associate Dean of the College of Engineering from 2019 to 2022 and the founding Deputy Director of Research Centre for Nature-Inspired Engineering from 2021 to 2022 at CityU. He is currently the Executive Editor-in-Chief of Droplet journal (Wiley).
Professor Wang is a founding member of the Hong Kong Young Academy of Sciences, Fellow of the International Society of Bionic Engineering (ISBE), Croucher Senior Research Fellow (2023), RGC Senior Research Fellow (2022), Highly Cited Researcher (Cross-field) recognized by Clarivate (2022), and Changjiang Chair Professor conferred by Ministry of Education of China (2016). His work has been recognized by the Guinness Book of World Records and two inventions have won the International Exhibition of Inventions of Geneva Gold Medal and Gold Medal with Congratulations of Jury, respectively. He has received many awards including the Falling Walls Science Breakthroughs of the Year 2023 (Engineering & Technology), Green Tech Award (2021), Xplorer Prize (2020), Hall of Fame (Advanced Engineering Materials, 2019), 35th World Cultural Council Special Recognition Award (2018), President's Lectureship (2020, 2018), Outstanding Research Award (Senior, 2017), President's Award at CityU (2017, 2016).

Abstract

A defining feature of living organisms lies in their efficient use of surfaces to dynamically interface with environments for a continuous flux and exchange of water, energy, heat, and information. The ubiquity and diversity of elegant natural surfaces inspire us to construct a wide range of functional surfaces. Despite extensive progress, it appears challenging to design, manufacture and adopt artificial surfaces that exhibit high performances as their natural counterparts. The challenges originate from the complexity in adopting one surface design and multiscale manufacturing to resolve many seemingly contradictory properties to yield optimized functions for many practical applications, especially in harsh environments.
In this talk, I will discuss how to design, manufacture nature-inspired surfaces with tailored complementary properties in topography, wetting, thermal/electrical conductivity, stiffness to overcome the inherent tradeoff otherwise associated with homogeneous design for water, energy, environment and healthcare applications.

Ultimate Condensation of X-Ray Free Electron Laser Down to Single Nanometer Size by Precision Mirror Devices

Yamauchi Kazuto
Division of Precision Science & Technology and Applied Physics
Osaka University

Biography

He has been a Professor at Osaka University since 2003 and has been a leader of the center of excellence for atomically controlled fabrication processes since 2008. He received PhD in 1991 from Osaka University. His working fields are precision engineering and its application to optics manufacturing, especially for X-ray and high power laser optics. He has been recognized as a fellow of SPIE and OSA, respectively, since 2017 and 2018. In 2023, he was awarded the Medal with Purple Ribbon from Japan.

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Abstract

Mirror devices are attractive to condense X-rays because of their achromaticity, large acceptance, high throughput, long working distance, and so on, compared with other devices such as lenses and Fresnel zone plates. Currently, focused beams with sizes of several tens of nanometers are commonly provided by mirror devices. However, in the ultimate condensation down to a single nanometer size, the required shape accuracy becomes unprecedentedly high to be less than 1nm in peak-to-valley over the whole area of the mirror surface with a 100mm scaled size. We have developed two kinds of deterministic fabrication processes utilizing visible laser interferometer metrology and at-wavelength metrology, and we have achieved an ultimate condensation of Japanese X-ray free electron laser, SACLA (Spring-8 Angstrom Compact free electron LAser), down to 7nm. We will explain the deterministic manufacturing methods of precision mirror devices and represent experimental results of the world's first observed non-linear optical phenomenon in the X-ray regime.

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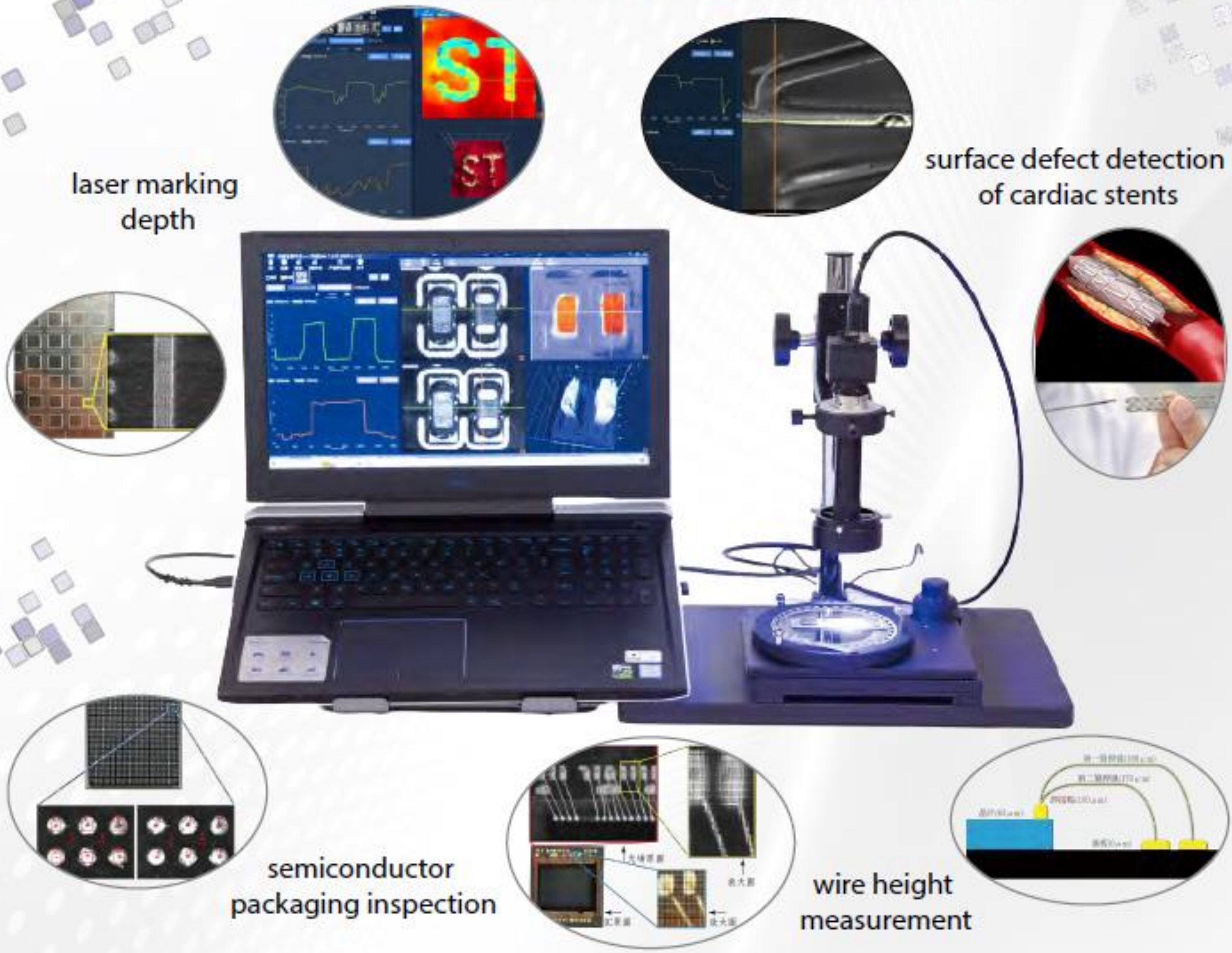

Compared to laser, structured light, and time-of-flight (TOF) cameras, light field cameras have fewer restrictions on light sources or lenses, are compact in size, offer interchangeable lenses, have simple optical components, and provide high-precision three-dimensional information with extended depth of field. They are also suitable for upgrading or sharing existing optical equipment. As a result, light field cameras offer greater flexibility and relatively lower overall hardware costs, installation, and maintenance.

Light field cameras find applications in the semiconductor industry, such as measuring the coplanarity of SoIC lead-out pins, measuring the height of BGA balls, measuring wireframe structures, measuring the height of IC wire arcs, and measuring the thickness of wire bonds on Micro LED PCBs. They are also used in other industrial fields, such as the inspection of precision mechanical parts and medical instruments.

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Session Keynote Speeches

Force Rheological Polishing Technology and its Research Progress

Julong Yuan
Ultra-Precision Machining Center
Zhejiang University of Technology

Biography

Julong Yuan is a senior professor at Zhejiang University of Technology and enjoys the special government allowance expert from the State Council of China. He is also recognized as a young and middle-aged expert with outstanding contributions in Zhejiang Province. He earned the bachelor, master, and doctoral degrees from Mechanical Engineering Department of Harbin Institute of Technology between 1979 and 1989. He served as a postdoctoral researcher and associate professor at Department of Mechanical Engineering, Zhejiang University from 1989 to 1998. He also pursued postdoctoral research at Kyushu University in Japan during this period. Currently, Julong Yuan holds the position of director of the Ultra-Precision Machining Center at Zhejiang University of Technology. He is concurrently the director of the Key Laboratory of Special Precision Grinding in Mechanical Industry and has previously served as the director of the National Engineering Research Center for High Efficiency Grinding at Hunan University. He is also the founder and organizer of the Xihu Swording Salon - International Forum on Advanced Precision Manufacturing and the Silk Road Symposium on Advanced Manufacturing (SAM). He serves as the Chinese Chairman of the China-Japan International Conference on Ultra-Precision Machining Process (CJUMP).

Julong Yuan has several academic roles, including serving as the Executive Council Member of the Production Engineering Subsociety of the China Mechanical Engineering Society. He is the Deputy Director of the China Abrasive Technology Committee, the Deputy Director of the China Precision Machining and Nanotechnology Committee, and the Deputy Chairman of the Cutting Advanced Technology Research Society of China. Additionally, he is a committee member of the International Abrasive Technology Committee and a full member of the Japan Society for Precision Engineering.

Throughout his career, Julong Yuan has been dedicated to teaching and research in precision and ultra-precision machining technology and equipment. He has led over 30 national and government technology projects and served as an editorial board member for journals such as the "Journal of Mechanical Engineering," "China Mechanical Engineering," and the "International Journal of Abrasive Technology." He has published over 300 academic papers both nationally and internationally and has authored five books. And he has been granted over 60 invention patents and has received two second-class National Science and Technology Progress Award, as well as six first-class awards at the provincial and ministerial levels.

Abstract

Force rheological polishing is a technology that utilizes the non Newtonian properties of fluids to high efficiently and ultra precision polish the surface of workpieces. This report introduces the principle of force rheological polishing and its application examples in various surface polishing.

Micro/nanostructured Material Generation from Silicon Waste-toward Material Resource Sustainability in Ultraprecision Machining

Jiwang Yan
Department of Mechnical Engineering
Keio University

Biography

Jiwang Yan received his Ph.D. from Tohoku University in 2000 and is currently a Professor of Mechanical Engineering at Keio University, Japan (2012-), leading the Laboratory for Precision Machining and Nano Processing. As adjunct positions, he was appointed as a Leverhulme Visiting Professor at The University of Manchester, UK (2018-19), and serves as a Specially Appointed Professor at Tokyo Institute of Technology (2017-). His research areas include ultraprecision machining, micro/nano manufacturing, laser processing, nanomaterial and nanomechanics. As a principal investigator, he has led more than 20 nationally funded projects and over 70 joint research projects with industry. He has authored/co-authored 300+ peer-refereed journal papers, given 150+ keynote/invited talks, and received 40+ awards for his contribution in the manufacturing area. He is the chief-editor of handbook "Micro and Nano Fabrication Technology" (Springer 2018) and the author of book "Micro Nano Scale Laser Processing of Hard Brittle Materials" (Elsevier 2019). He is an executive director of JSPE and the chairman of publication sector and also serves the board of JSLT and the editorial boards of several international journals including IJMTM and IJEM. He is member of JSME, JSPE, JSAP, JSAT, ASPE, SME, euspen and CIRP, and fellow of ISNM.

Abstract

A huge amount of silicon waste is discharged from semiconductor and solar cell manufacturing processes, such as wafer slicing and grinding, which has become a crucial problem for material resource sustainability. In this talk, novel processes for silicon-based micro/nanostructured material generation from the slicing/grinding chips will be introduced, which provides potentials for fabricating silicon-based anodes for lithium-ion batteries. One example is generating micro silicon pillar on copper foils by laser irradiation. The fabricated pillar-on-foil structures were used as anodes for lithium-ion batteries and could effectively accommodate the volume expansion of silicon caused by ion storage with excellent discharge capacity and cycle characteristics. Another example is laser-induced core-shell nanoparticle/nanowire generation from silicon waste, which provides a sustainable material resource for manufacturing anodes of future high-performance lithium-ion batteries.

Surface Integrity of Ti6Al4V Subjected to High-speed Grinding

Bi Zhang
College of Engineering
Southern University of Science and Technology

Biography

Bi Zhang, Chair Professor of Mechanical and Energy Engineering, Southern University of Science and Technology. He has been engaged in long-term research on the fundamental theory and processes of high-speed precision machining, especially on difficult-to-machine materials. He is a fellow of The International Academy for Production Engineering – CIRP, and of The American Society of Mechanical Engineers – ASME, an associate editor of the International Journal of Extreme Manufacturing, and on the editorial board of the English edition of the Chinese Journal of Mechanical Engineering.

Abstract

High-speed grinding has been applied to difficult-to-machine materials for many industries. The talk will start with the fundamental theories in high-speed machining, with a focal point on surface integrity in high-speed grinding of Ti6Al4V. Experimental results will be reported on single-point and wheel grinding of the Ti6Al4V workpieces with a hierarchically ultrafine grain embedding structure through ultra-high strain rate deformation, and a transition from dislocation-mediated deformation to twin-mediated deformation under the ultra-high strain rate conditions. The talk also demonstrates how grinding-induced damage is significantly suppressed by increasing grinding speed, so as to improve the surface integrity of a ground Ti6Al4V workpiece.

Photoelectrochemical Mechanical Polishing (PECMP) Theory and Technology for GaN Substrates

Zhigang Dong
State Key Laboratory of High-Performance Precision Manufacturing
Dalian University of Technology

Biography

Dong Zhigang is a professor and doctoral supervisor at the School of Mechanical Engineering at Dalian University of Technology, and the director of the Institute of High Performance Manufacturing. He is also the recipient of the National Science Foundation for Distinguished Young Scholars, the top young talent in the National "Ten Thousand Talents Plan", and the expert of the 14th Five Year Key R&D Plan Group of the Ministry of Science and Technology. He received his Bachelor of Engineering Dalian University of Technology in 2002 from and Ph.D. of Engineering from the University of Queensland and Dalian University of Technology in 2010. He has won the second award of China National Technology Invention Award, Silver Award of China Patent Award and the first award of Technology Invention Award of Liaoning Province. He is a member of International Conference Abrasive Technology (ICAT) and a member of Extreme Manufacturing Institution of Chinese Mechanical Engineering Society. His researches focus on high-efficiency machining of difficult-to-cut materials and precision/ultra-precision processing technology and equipment. He has published over 150 journal papers, and obtained 7 international invention patents and more than 140 Chinese invention patents.

Abstract

Gallium nitride (GaN) material has excellent properties, including high thermal conductivity, strong breakdown field, and high-temperature resistance. Thus, GaN is widely used in aerospace, artificial intelligence, and among fields. However, high hardness and strong chemical stability of GaN material lead to low polishing efficiency, which seriously restricts its application. For the issue of an extremely low material removal rate of GaN substrate processing, a new method called Photoelectrochemistry Mechanical Polishing (PECMP) was proposed and a PECMP processing system based on photoelectric chemical adaptability was constructed. The influence of photochemical action on the material removal during the processing was studied to reveal the material removal mechanism and the formation mechanism of the super-smooth surface of GaN substrate PECMP processing. Further, the reasonable process conditions and process parameters of GaN substrate PECMP were determined and the PECMP principle prototype and engineering prototype were developed. Low damage and efficient processing of GaN substrate using PECMP can be achieved. The polishing efficiency is improved by more than one order of magnitude compared with the traditional CMP process.

Comb-based Optical Frequency Synthesizer for Precision Metrology with 15-digit Accuracy

Seung-Woo Kim
Department of Mechanical Engineering
Korea Advanced Institute of Science and Technology

Biography

Prof. Seung-Woo Kim obtained his bachelor degree in Mechanical Design from Seoul National University in 1978, and received his MS degree in Mechanical Engineering from the Korea Advanced Institute of Science and Technology (KAIST) in 1980. He went over to United Kingdom in 1981 for further study and obtained his Ph.D. degree in Precision Machine Systems Design from Cranfield University in 1984. He came back to Korea and started his carrier as a scholar by joining KAIST in 1985. During the last 38 years in the Department of Mechanical Engineering, he has been teaching and leading a research group of graduate students, producing 70 PhD graduates under his supervision. His professional interests are precision optical technology with specialty on optical-mechanics system synthesis for precision machines design, optical interferometry for 3-D surface and thin-film metrology, and ultrafast photonics for nano-scale fabrication and ultra-precision measurements. He has published ~ 400 technical papers, ~ 600 presentations in conferences, and ~ 80 patents. He has been working as principal investigator for numerous national and industrial research projects and currently involved in an important national creative research initiative project for the development of next generation precision engineering key technologies using femtosecond pulse lasers. He has also actively been involved in international academic societies for organizing on-time conferences for leading-edge precision engineering optical technologies. He was president of the Korea Society of Precision Engineering (KSPE) during the term of 2011 and is currently a member of OSA (Optical Society of America), SPIE (International Society of Optical Engineering) and CIRP (International Academy for Production Engineering).

Abstract

A talk will be given on the optical frequency synthesizer developed at KAIST, South Korea based on the optical frequency comb created from an Er-doped fiber laser. Being stabilized to an ultra-low expansion (ULE) glass cavity with a fractional frequency stability of 3.8×10^{-15} at 0.1s averaging, the comb-rooted synthesizer is configured to produce multiple optical frequencies of ultra-narrow linewidth of 1.0 Hz at 1s with an output power of tens of mW per each channel concurrently. Diode-based stimulated emission by injection locking is a key mechanism that allows comb modes to sprout up with sufficient power amplification but no loss of original comb frequency stability. Multi-channel frequencies are individually selectable with a 0.1GHz increment over the entire comb bandwidth spanning 4.25THz around a 1550nm center wavelength. A series of out-of-loop test results is discussed to demonstrate that the frequency synthesizer is able to provide stable frequencies not only in the optical domain but also in the microwave and Terahertz ranges by heterodyning two comb modes arbitrary chosen. Such output frequencies will permit diverse applications to be accomplished with 15-digit accuracy particularly in the fields of interferometric dimensional metrology, optical clocks comparison, absorption spectroscopy, photonic microwaves generation, and coherent optical telecommunications as illustrated in Fig. 1.

In-process Form Profile Optical Measurement under Coolant Condition

Yongsheng Gao
Department of Mechanical and Aerospace Engineering
The Hong Kong University of Science and Technology

Biography

Dr. Yongsheng Gao's research is in precision machining and precision in-process optical measurement. He has published more than 200 journal and conference papers, jointly co-edited 6 conference proceedings and 2 journal special issues, with 12 invention and utility patents granted by the US and China. Dr. Gao also supervised 5 PhD students who now become professors of top Chinese universities and entrepreneur of industry who are internationally competitive. Dr. Gao successfully organized 2 international conferences in precision machining and precision measurement. Dr. Gao was a co-founder of the International Committee for Abrasive Technology in 2002 and is the general secretary of the International Committee on Measurements and Instrumentation since 2003, both organizations have successful international conferences on annual and biannual basis, respectively, for specialists of the precision engineering field worldwide.

Abstract

In-process measurement provides feedback for control of workpiece precision in terms of size, form error, and roughness. It can be used for precision control of a machining process to improve productivity and reduce defect rates. To avoid workpiece surface scratch and measurement stylus wear, non-contact methods are more favorable when compared with contact methods. Optical measurement methods are of the non-contact type and possess high precision. Therefore the methods of the kind should be used for in-process form profile measurement.

In precision machining, opaque coolant is commonly used to reduce heat generation and thermal deformation on workpiece surface. However, use of coolant will introduce an opaque barrier problem if the optical measurement methods are used.

To solve this key opaque barrier problem, several approaches have been proposed by Gao et al, including the water beam approach, the single air beam approach, the multiple air beam approach, and also the dual coolant displacing medium method. The key technique in the proposed methods is the use of assisting fluid beams to overcome the opaque barrier of coolant to build a small zone that is optically clean, which is termed as transparent window. This will allow the workpiece surface y(x, z) accessible to an optical measurement system of choice.

In this paper, models of the proposed methods are introduced together with the working principles and the key features of the four methods. New in-process form profile optical measurement systems are developed, which are capable of measuring workpiece surface y(x, z) at high precision under coolant condition. Measurement system performance tests are presented. Coolant removal capabilities of the four methods and performance enhancements are also discussed.

Experimental results show that workpiece surface y(x, z) can be measured successfully with the standard deviation up to 0.301 μm even under a massive amount of coolant where the coolant thickness is 15 mm, a relative uncertainty of 2□ up to 4.35% and the workpiece surface deeply immersed in the opaque coolant, a condition under which so far no existing systems are able to perform and deliver.

Challenges in Electrochemical Machining

Masanori Kunieda
Tokyo University of Agriculture and Technology
The University of Tokyo

Biography

Professor Masanori Kunieda received his PhD from the University of Tokyo in 1985. He worked for Tokyo University of Agriculture and Technology and the University of Tokyo for 38 years, retiring in 2023. He is now an emeritus professor at both universities and a technical advisor to FANUC and Sodick. His main areas of research are electrical discharge machining and electrochemical machining. He has authored 267 refereed journal papers and received 61 awards. He has supervised 23 PhD students and 80 Masters course students. He has served as President o f the Japan Society of Electrical Machining Engineers and is currently Vice president of the Japan Society for Precision Engineering and Editor in Chief of the J. of Int'l Soc. for Precision Engineering and Nanotechnology.

Abstract

Electrochemical machining (ECM) is known as a promising method that can machine difficult-to-machine metallic materials with high efficiency and smooth surface roughness compared to electrical discharge machining (EDM). However, it is difficult to achieve higher machining accuracy than EDM because the gap width in ECM is larger than in EDM. In addition, the gap width distribution is likely to be uneven because the temperature rise due to Joule heating and bubble formation locally change the electrical conductivity of the electrolyte, making it difficult to reproduce the tool geometry on the workpiece. Therefore, ECM micromachining is difficult for the same reason. In addition, while any electrically conductive material can be machined by EDM, refractory materials such as tungsten, titanium, and chromium, which are easily passivated, are difficult to dissolve without the use of toxic chemicals. Finishing tungsten carbide and tool steel is also difficult because the multi-phase microstructure and carbide precipitates hinder smooth surface finishing due to the uneven distribution of electrochemical potentials over the workpiece surface. Therefore, this keynote will present some challenges to overcome these problems. First, the inter-electrode gap phenomena are visualized using a transparent electrode to understand the detrimental influence of bubbles unevenly distributed in the gap on machining accuracy. Subsequently, ECM was performed in a stationary electrolyte using the newly developed stamp flushing method to obtain a uniform gap width distribution. Micromachining of tungsten and tungsten carbide was carried out using a bipolar pulse. The bipolar pulse was also useful for obtaining a smooth surface in processes such as electrolyte jet machining and wire electrochemical machining, in which the workpiece surfaces are scanned by tool electrodes.

Evolution of Space Optical Systems: ----From Aspheres to Freeforms

Xuejun Zhang
Changchun Institute of Optics Fine Mechanics and Physics, Chinese Academy of Science

Biography

Xuejun Zhang received his Ph.D. degree from the Changchun Institute of Optics and Fine Mechanics and Physics (CIOMP) in 1997. He is now Director of CIOMP. Dr. Zhang has been engaged in optical system design, manufacturing, and testing for more than 20 years, and led his team in achieving a major breakthrough in the high-precision manufacturing technology of 4.03 meter SiC mirrors. The overall results are of a world-leading level. He is also the team leader of the 30 Meter Telescope (TMT) Tertiary Mirror Manufacturing project. As principal investigator, he has completed a number of national research projects and won five National Awards for Achievements in Science and Technology. He was supported and rewarded by the National "Outstanding Youth" Fund, the Qian Xuesen Outstanding Contribution Award of the China Aerospace Foundation, and the Science and Technology Award of the Chinese Society for Space Science. Dr. Zhang is a Fellow of SPIE and a member of OSA and has published 185 peer-reviewed papers.

Abstract

Over the last decade, the performance of space optical systems has been significantly improved through the efforts of optical researchers in China and abroad. Two critical specifications of an Earth Observing (EO) system are resolution and swath. By this measure, China's recently launched commercial EO systems have reached a world-class level. These inspiring achievements are the results of courageous innovations and substantial practices in reflective optical materials, optical design, aspheric fabricating and testing, and system assembly.
Advanced manufacturing technologies of optical systems include mirror blank preparation, optical design, fabrication, coating, testing, and system assembly, which is an enabling technology for high-performance optical systems. The imaging optical system is an information-collecting system, and an important indicator to assess its performance is the information-collecting capacity. For example, the requirements for the EO payloads are higher resolution and wider imaging swath. However, constrained by launch costs and working environments, the volume and weight of space optical systems are strictly restricted. Therefore, some common requirements for its manufacturing technology are summarized as follows. First, the mirror materials should have high specific stiffness and thermal deformation resistance to reduce the cost of launch weight and thermal control. Second, the systems with the large aperture, long focal length, and large field of view (FOV) simultaneously are needed to solve the contradiction of high resolution and wide swath, and this results in multiple-mirror on-axis or off-axis design. Aspheric surfaces or even freeform surfaces are employed to increase the design freedom and balance the large off-axis field aberrations. Nevertheless, the off-axis aspheric or freeform design causes asymmetric mirror shape and system layout. Consequently, unlike the conventional slow-lapping process, the deterministic computer-controlled optical surfacing (CCOS) technique is necessary to

achieve higher accuracy and efficiency. Meanwhile, aspheric surface digital testing and system computer-aided alignment techniques are utilized through the whole process of milling, grinding, polishing, and system assembly to guide deterministic processing and verify the payload’s performance consistency in space and on earth.

In this talk, the latest progress of space optical systems over the last decade in China are introduced with the combination of several on-orbit examples. The technological advantages include silicon carbide (SiC) material, space optical system design and configuration evolution, digital measurement of complex optical surfaces, and computer-aided assembly and adjustment technology. In addition, the future trend of advanced optical system manufacturing technology is discussed.

Fully Automated Additive Manufacturing Using Directed Energy Deposition (DED)

Hideki Aoyama
Faculty of Science and Technology
Keio University

Biography

Dr. Hideki Aoyama is an emeritus professor at Keio University. He received a doctoral degree from Hokkaido University in Japan. From 1992 to 1993, he was a visiting researcher at the University of California, Davis. In 1996, when he became an associate professor at Keio University, he established a digital design & digital manufacturing laboratory.

Emeritus Professor Aoyama served as the president of the Japan Society for Die and Mould technology (JSDMT) in 2016 and 2017. He was the chairman of the International Committee for Abrasive Technology (ICAT) in 2016 and 2017. He also served as a vice president of the Japan Society for Precision Engineering (JSPE) in 2018 and 2019.

In research activity, he developed digital design methodology that automatically create aesthetic design based on mathematical models of natural phenomena. He also developed many automatic systems including manufacturing inspection with AI, process planning and NC program generation for multi-axis machine tools, and high-speed/high-accuracy machining for free curved surfaces. Recently, he is especially interested in developing automatic molding system using a metal 3D printer (DED) and developing a femto-second laser ablation system.

Abstract

The talk of Emeritus Professor Aoyama is about “Fully Automated Additive Manufacturing Using Directed Energy Deposition (DED)”. In the processes of DED, the standoff distance (SOD), which is the distance between the melt pool and the powder injection nozzle, must be unstable. The unstable SOD makes a model-shape inaccurate, makes model-quality uneven, and sometime makes modeling impossible. Since the SOD is unstable, modeling using DED requires a lot of trial and error. Emeritus Professor Aoyama has developed a fully automated DED system which can execute modeling by just giving the CAD data of a required shape. The DED system measures the SOD in-process and generates modeling paths keeping the optimum SOD in real time. The DED system also makes it possible to automatically add additional printing to areas with insufficient shape for achieving high-precision printing.

In-situ Field Assisted Ultra-precision Machining: Theory, Technology and Equipment

Jianfeng Xu
National Key Laboratory of Intelligent Manufacturing Equipment and Technology
School of Mechanical Science & Engineering
Huazhong University of Science and Technology

Biography

Prof. Jianfeng Xu received the B.S. degree from the School of Mechanical Science and Engineering, Huazhong University of Science and Technology in 2001, and the Ph.D. degree in mechanical engineering from the University of California at San Diego in 2008. He has worked in Western Digital and Applied Materials with engineering position from 2008 to 2012. Since 2012, he has been a Professor at School of Mechanical Science and Engineering, Huazhong University of Science and Technology. Currently he serves as vice dean of School of Mechanical Science and Engineering and vice director of State Key Lab of Intelligent Manufacturing Equipment and Technology. His research interests include precision machining technology and intelligent manufacturing system.

Abstract

As it is difficult to satisfy the requirements of ultra-high surface quality and accuracy by applying a single type of ultra-precision machining method, an in-situ field-assisted machining technology was proposed for the ultra-precision machining of the difficult-to-cut materials in the aerospace, advanced optics and high-performance ray detection devices. The high-precision energy field control, the material removal and failure mechanism and the high-quality surface forming mechanism were investigated and clarified in the field-assisted ultra-precision machining process. Hence, the arbitrary control of energy morphology, the nano-level material removal and the low damage surface generation are successfully achieved. The hard-brittle single crystal silicon with diameter over 80 mm has been efficiently and accurately fabricated by applying the diamond cutting technology. The profile error, surface roughness and the subsurface damage is less than 0.3μm, 0.5nm and 10nm respectively. Furthermore, the multi-field-assisted ultra-precision machining technology is innovatively proposed, and potential applications in infrastructure of national science and technology development are discussed.

Advancements in Optical Metrology for Next-generation Semiconductor Packaging

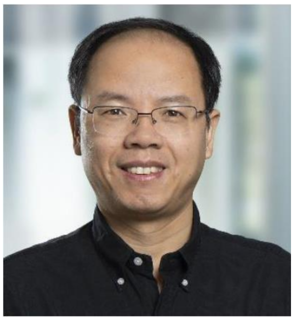
Liang-Chia Chen
Department of Mechanical Engineering
National Taiwan University

Biography

Dr. Liang-Chia Chen is a full-time professor in the Department of Mechanical Engineering at National Taiwan University (NTU). He earned his Ph.D. in advanced manufacturing and mechanical engineering from the University of South Australia in 2000. His research specializations include precision metrology and manufacturing, semiconductor metrology, automated optical inspection (AOI), and 3-D machine vision algorithms for automation. He has been recognized with multiple awards including two outstanding research awards from the Ministry of Science and Technology (MOST) of Taiwan in 2016 and 2021, consecutive National Year Invention gold awards in 2013 & 2014, and a 2014 outstanding award on technology transfer from MOST. To date, he has authored a textbook, three book chapters, over 120 peer-reviewed journal papers, and holds 60 international patents. He served as the president of the International Committee of Measurement and Instrumentation (ICMI) from 2015-2017 and is now a steering committee member in both ICMI and IMEKO. Additionally, he is involved in ISO as a board member in TC14. Dr. Chen is affiliated with multiple professional organizations including SPIE, SME, IEA, CIE, TSPE, AOIEA, CIAE, and CMS.

Abstract

The talk will explore recent innovations and hurdles in optical metrology on advanced semiconductor packaging. As miniaturization progresses, optical metrology emerges as an indispensable tool in industries like semiconductor manufacturing, attributed to its non-contact, high-resolution, and swift measurement abilities, making it pivotal in advanced processes such as automated optical inspection (AOI). Yet, the emerging need for precise 3D integrated circuit packaging characterization in semiconductors introduces sizable challenges in optical metrology. Addressing these challenges is crucial to cater to stringent in-line process requisites. This presentation will outline predominant optical measurement techniques in semiconductor production, including CD-SEM, X-ray or EUV scatterometry, reflectometry for OCD metrology, AFM, Superoptics for imaging, white light interferometry, and confocal microscopy. The talk tries to shed light on their inherent constraints while anticipating breakthroughs. Furthermore, the talk will illuminate recent progress in optical metrology, offering a perspective on the evolution of various techniques and existing technological barriers.



Accurate and Traceable Reference Nano Dimensional Metrology

Gaoliang Dai
3D Nanometrology
Physikalisch-Technische Bundesanstalt (PTB)

Biography

Dr. Gaoliang Dai is currently a research scientist and head of the working group “3D nanometrology” at the Physikalisch-Technische Bundesanstalt (PTB) – the national metrology institute of Germany. Gaoliang gained a BSc and a PhD in optical engineering from the Tsinghua University, P. R. China, in the year of 1994 and 1998, respectively. He was a R&D engineer in the Physik Instrument (PI) GmbH & Co till the year 2001 before he joined the PTB. His research interests including the dimensional nanometrology, nanopositioning, interferometry, AFM and TEM techniques. He has received research fundings from EMPIR, ECSEL JU, ENIAC JU, TransMeT and industry in over ten projects. He has authored more than 100 papers in peer reviewed highly ranked journals, as well as offered a number of keynote and invited presentations in international conferences.
Gaoliang serves as an editorial board member for the journals Nanomanufacturing and Metrology, Metrology and Measurement Technology. He is a council member of the International Committee on Measurements and Instrumentation (ICMI), and a member of the Metrology Focus Team of the IEEE-International Roadmap for Devices and Systems (IRDS). In addition, he is also a guest university professor, teaching lecture as well as supervising master and PhD students.

Abstract

Nanometrology covers a wide range of metrology techniques for enabling characterisation and measurement of nanomaterials, structures, components, devices, and systems at the nanoscale. Adequate nanometrology is key to innovations in nanotechnology and nanoscience, such as understanding the interaction mechanism between atoms, controlling nanomanufacturing processes, optimising nanoscale products as well as preventing nanotoxicity. Traceability is a fundamental issue for nano-dimensional metrology, and its absence inhibits the comparison of tools from different manufacturers, and limits knowledge about the real size of fabricated features.
This keynote paper will offer an overview of recent advancements for accurate and traceable nanoscale dimensional metrology, particularly using the atomic force microscopic (AFM) techniques. Research for two kinds of fundamental calibration tasks of nanometrology: (i) calibration of geometrical parameters (i.e. magnification, nonlinearity, orthogonality, etc.) and (ii) calibration of 3D parameters such as critical dimension (CD), line edge/width roughness (LER/LWR), sidewall angle (SWA), etc., will be focused.
Some selected application examples of the developed nanometrology techniques will be demonstrated, for instance, (i) development of an extreme ultraviolet (EUV) photomask standard; (ii) calibration of various nanoscale standards; and (iii) development of a novel material measure for characterising 2D Instrument Transfer Function (ITF) of various optical areal surface topography measurement tools.

Non-isothermal Hot Embossing Molding of High Melting Point Glass Lens

Lihua Li
Sino-German College of Intelligent Manufacturing
Shenzhen Technology University

Biography

LIHUA LI received the B.Sc. degree in School of Optics and Photonics from Beijing Institute of Technology, Beijing, China, and the Ph.D. degree in Department of Precision Instrument from the Tsinghua University, Beijing, China, in 2004 and 2012, respectively. She has been a Research Associate and a Scientific Officer with the State Key Laboratory of Ultra-precision Machining Technology, Hong Kong Polytechnic University, Hong Kong, China, since January 2010 and September 2013, respectively. Currently she is an Academic Leader and Professor in Sino-German College of Intelligent Manufacturing, Shenzhen Technology University, Shenzhen, China. Her research interests include ultra-precision machining technology, advanced optics design, precision manufacturing, testing and its applications.

Abstract

Since glass optical elements have the advantages of high transparency, there is a growing demand of glass optical elements with high precision and low cost. And hot embossing technology (isothermal/non-isothermal) for the manufacturing of glass optical elements is the mainstream research direction.

Isothermal hot embossing technology needs to heat the whole cavity (mold core, mold frame, protective coating and glass), while non-isothermal hot embossing technology only needs to heat the mold core. At the same time, it simplifies the temperature control and pressure control system and overcomes the deficiencies of isothermal hot embossing technology (long processing cycle, high energy consumption and low efficiency, etc.).

We proposed a non-isothermal hot embossing technology for high-efficient and low-cost optical elements fabrication in various shapes. It only heated the coating and glass on the mold core surface to increase the heating rate and reduce energy consumption. On this basis, we analyzed the consistency of mold core and glass lens surface profile, and proposed a process parameter presetting method based on thermal simulation and an intelligent glass hot embossing machine control method based on PC-PLC. The technology can be used for fabricating various lenses such as spherical surfaces, aspherical surfaces, and freeform surfaces (including microlens arrays), and has the advantages of high production efficiency and economic benefits.

Recent Development of Ultra-precision Machining for Optical Applications

Kui Liu
Machining Technology Group
Singapore Institute of Manufacturing Technology (SIMTech)

Biography

Dr Liu Kui currently is a Principal Scientist in the Singapore Institute of Manufacturing Technology (SIMTech) focusing on novel machining technology development. He received his BEng and MEng degrees from Nanjing University of Aeronautics and Astronautics in 1989 and 1996, and PhD degree from the National University of Singapore in 2002. Dr Liu's research interests include ultra-precision machining, ductile mode machining, nano/micro machining, hybrid machining, robotic machining, magneto-rheological finishing, gun drilling, micro EDM and diamond tool fabrication. He has carried out in both fundamental research and industry-based research, and some technologies developed have been implemented by the industry. He has authored 1 monography, co-authored 1 book and 6 book chapters, published 200 papers in prestigious international journals and conferences, filed 4 patents and 24 technical disclosures. He also serves an associate editor and editorial board member of serval international journals such as IJEM, NMME, Machines and DAE.

Abstract

Ultra-precision machining (UPM) is a key technology in the manufacturing of mechanical, optical and optoelectronics components achieving a surface roughness with few nanometers and form accuracy in sub-micrometer range. Discontinuous microstructures are increasingly used to enhance technical surfaces with additional functionalities, and the design of such microstructures also become more complicated and sophisticated for specific applications. Currently, it is impossible for conventional diamond turning to generate the large-scale discontinuous microstructures due to the loss of rotational symmetry of axis in the freeform structures, resulting low productivity, poor dimensional control, etc. Hence, manufacturers and researchers often choose to produce them by diamond cutting each individual segment and assembling all the segments together. We are working on ultra-precision machining by employing novel technologies/approaches, such as in-situ multiple-axes freeform machining processes, to fabricate complex and discontinuous microstructures on monolithic parts. This greatly improves the form accuracy of the generated surface while eliminating any lead time lost via the multiple iterations of setup, form measurement, repair, and reassembly.

Micro/nano Measurement Technology and the Application in IC

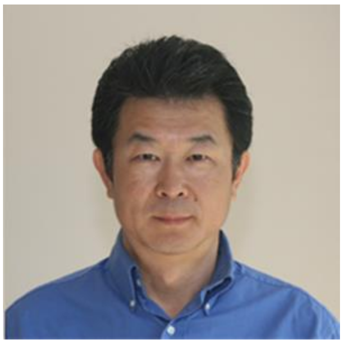
Shuming Yang
School of Mechanical Engineering
Xi'an Jiaotong University

Biography

Prof. Dr. Shuming Yang is from Xi'an Jiaotong University (XJTU), China. His main research interests include nanofabrication and measurement, optical measurement and instrumentation, ultra-precision manufacturing and measurement etc. He has held more than 20 research projects including National Science Fund for Distinguished Young Scholars, National Key R&D Program of China, National Science and Technology Major Projects etc. He has published more than 200 papers and 2 books, owned over 100 patents of PCT, UK, European and China, achieved 9 technical awards. He was elected as a fellow of the International Society for Nanomanufacturing (ISNM), and a council committee member of Asian Society for Precision Engineering and Nanotechnology (ASPEN) etc. He is also an editor or a guest editor of JMS, IJPEMGT, IJRAT, NMME, MST, PE, IJAMT, Photonics etc. He delivered keynote and invited talks in academic conferences for more than 60 times.

Abstract

This report will introduce nano probes including plasmonic optical probe, carbon nanotube probe, and composite nano probe. The controllable fabrication process of plasmonic optical probe will be discussed, and an imaging system has been built to realize the nanofocusing of surface plasmons induced by the optical probe. The growth solution pick-up method and plasma method will be proposed to achieve controllable preparation of large aspect ratio carbon nanotube probes. It has effectively solved the challenge of measuring 3D nanostructures with high aspect ratios. The composite probe has further been made by a carbon nanotube probe integrated with an optical probe. Moreover, the report will also introduce the application of the probes in IC.



High Volume Replication of Micro and Nanoscale Optical Surface Structures

Allen Yi
Department of Systems Engineering
The Ohio State University

Biography

Professor Allen Yi received his Ph.D. in mechanical engineering from Boston University in 1993. He subsequently joined Corning Precision Lens as a staff scientist. In 2002, Professor Yi joined The Ohio State University as an assistant professor. He was promoted to associate professor with tenure in 2008 and to full professor in 2012. His research activities have been in the general area of precision engineering with a focus on high volume optical fabrication, freeform and microoptics fabrication as well as micromachining processes for medical and biomedical device fabrication. Professor Yi's current research interests include compression molding of glass optics and injection molding of high precision polymer optics. He has more than 80 referred journal publications, and one US patent. He has been the coordinator and member of the ASPE (American Society for Precision Engineering)'s scholarship review team. He chaired the spring topical meeting on micro and nano scale biomedical device fabrication for ASPE in 2005 and also served as session chairs at many ASPE annual meetings. Outside ASPE, he frequently participates in the conferences at EUSPEN and ASPEN. Professor Yi is an associated editor for *Advanced Optical Technologies* and *International Journal of Extreme Manufacturing*.

Abstract

In this presentation, we will report recent progresses in compression molding of precision glass optics using both soft PDMS (polydimethylsiloxane) and hard (nickel and nickel alloys) mold inserts and describe the advantages and limitations of each process. In an innovative approach, a single Fresnel microlens was diamond machined on brass substrate. The brass part was then used as a stamper to create a Fresnel microlens array on PMMA (polymethylmethacrylate) substrate. A PDMS mix was then cast off the plastic substrate to form the lens array replica. Using a non iso thermal forming process chalcogenide glass lens arrays with high fidelity were molded. In the second experiment, a PMMA master of a harmonic diffractive lens was machined using single point diamond turning. Then an electrolytic plating process was conducted to grow a reverse nickel mold. Compression molding was performed using the nickel mold to form the diffractive lens structures onto a glass surface. In both cases, surface measurements and optical testings showed that the replicated diffractive lenses have high tolerances with corresponding optical performance, demonstrating a high-volume, high precision and cost-effective process. Finally, we will discuss replication of anti-reflective surface structures and the possibility of forming metastructures using similar process.

Surface Modification of Biomedical Metals by Femtosecond Laser

Yung-Kang Shen
School of Dental Technology
Taipei Medical University

Biography

Professor Yung-Kang Shen received his Ph.D. degree from the National Taiwan University, Taipei, Taiwan, in 1995. He has been a Professor at the School of Dental Technology at Taipei Medical University (TMU) since 2014. He has been a Chairman of the School of Dental Technology of TMU since 2018. He is also the Director of the Bio-Medical Nano/Micro Forming Lab of TMU, the Researcher of the Nano Tissue Engineering and Image Research Center of Taipei Medical University Hospital (TMUH), the Researcher of the Sleep Research Center of Taipei Medical University Hospital (TMUH), the Researcher of the Department of Otolaryngology of Taiwan Adventist Hospital (TAH). He is the Chairman of the Taiwan Oral Biomedical Engineering Association, Co-Organizing Directors for the Asia Pacific Society for Materials Research (APSMR), Co-Organizing Directors for the Asia Pacific Society for Biology and Medical Sciences (APSBMS), the Supervisor of SME Taipei Chapter and the Director of Taiwan Society for Abrasive Technology. He has been an Adjunct Professor of University Airlangga (Indonesia) since 2022. He has been an Adjunct Professor of University Hasanuddin (Indonesia) since 2020. He has been a Guest Professor at Zhejiang University of Technology (China) since 2017. He has been a Part-time Professor at Shandong University (China) since 2016. He has been a Visiting Professor at Changchun University of Science and Technology (China) since 2012. Professor Shen is a project review committee member of the National Science and Technology Council (Taiwan). His research includes digital dentistry, metamaterial, scaffold fabrication (PCL/graphene), 3D/4D/5D printing, biomedical nano/micro forming technology, medical bionics design and manufacturing, and animal models for medicine therapy. Now, he has published more than 140 journal papers and 120 conference papers. Professor Shen has served as the Plenary Speaker or keynote speaker at more than 30 international seminars. Professor Shen was awarded the Best Paper Award for the 3rd International Forum on Systems and Mechatronics in Singapore in 2010. He was also awarded the First Prize in Poster Presentation Award for the 2nd Research Week-International Symposium 2012 of COM on Dental Technology, Oral Health Care, and Biomedical Devices in Taipei in 2012. He was also awarded the Most Cited Article Award, 2012 to 2013 for "International Journal of Precision Engineering and Manufacturing" (SCI Journal). Professor Shen was awarded the World’s Top 2% Scientists 2022-side by side of lifetime scientific influence (Stanford University). Professor Shen currently serves as the Editorial Board for Polymers (SCI Journal), Biology, Engineering and Medicine; Journal of Precision Medicine and Public Health; Open Access Journal of Science and Technology; International Open Access Journal of Translational Medicine; International Journal of Manufacturing Engineering; Japanese Journal of Medical Science and International Journal of Translational Science & Research.

Abstract

Most dental implants currently on the market are treated through surface sandblasting or acid etching, resulting in random and non-reproducible geometric shapes and surface roughness values. After implantation into the human body, this may lead to random orientations of bone cells, consequently causing the formation of scar tissue.

In this study, femtosecond laser processing was employed, which can precisely control and produce regular-shaped textures on the surface of biomedical metal (Ti6Al4V). The experiments varied laser fluence, scan speed, and scan number to create grooves, and holes with different widths and depths.

Biomedical metals with surface microstructures exhibited better hydrophilicity and higher surface roughness. When subjected to cell culture using MG63 cells, biomedical metals with microstructures displayed higher cell activity.

Interferometric Testing and Alignment of Multiple Optical Surfaces Based on CGHs

Shanyong Chen
College of Intelligence Science and Technology
National University of Defense Technology

Biography

Prof. CHEN Shanyong is from College of Intelligence Science and Technology, National University of Defense Technology (NUDT), Changsha, China. He received the B.S. degree and Ph.D. degree in Mechanical Engineering from NUDT in 2000 and 2006, respectively. His current research interests focus on optical testing, ultra-precision machining and measurement. He has published over 50 papers in learned international journals and referred conferences, and contributed 2 books. He holds one US patent and 20 China patents in the field of optical testing. He has presented over 20 invited talks in international or domestic conference sessions.

Abstract

Surface metrology plays a vital role in optics manufacturing, both in corrective figuring process which requires feedback of the surface error and in alignment of optical systems which requires monitoring the surface orientations. This talk presents interferometric solutions based on computer generated holograms (CGHs) to measurement and alignment of multiple optical surfaces for high profile imaging systems. The null testing of aspheres, off-axis aspheres, extended polynomial surfaces and cylinders/acylinders is introduced, in combination of subaperture stitching to extend the range of measurement. Special issues regarding the CGHs are discussed on uncertainty, traceability and correction of mapping distortion. CGH is versatile with multiple functional patterns fabricated on a single substrate, which makes it excellent for alignment of multiple surfaces. Examples are given for two coaxial aspheres, two off-axis surfaces with unparallel axes, back-to-back surfaces, face-to-face surfaces and a four-mirror telescope. Simultaneous measurement of multiple surfaces with orientations included facilitates alignment of telescopes. And the CGH-based testing allows design and corrective machining of monolithic multiple surfaces, which makes the adjustment-free assembly possible.

Digital Holography-based Micro-additive Manufacturing

Shih-Chi Chen
Department of Mechanical and Automation Engineering
Multiscale Precision Instrumentation Laboratory
CUHK-CAS Joint Laboratory for Precision Engineering
The Chinese University of Hong Kong

Biography

Dr. Shih-Chi Chen is a Professor in the Department of Mechanical and Automation Engineering at the Chinese University of Hong Kong. He received his B.S. degree in Mechanical Engineering from the National Tsing Hua University, Taiwan, in 1999; and his S.M. and Ph.D. degrees in Mechanical Engineering from the Massachusetts Institute of Technology, Cambridge, in 2003 and 2007, respectively. Following his graduate work, he entered a post-doctoral fellowship in the Wellman Center for Photomedicine, Harvard Medical School, where his research focused on biomedical optics and endomicroscopy. From 2009 to 2011, he was a Senior Scientist at Nano Terra, Inc., a start-up company founded by Prof. George Whitesides at Harvard University, to develop precision instruments for novel nanofabrication processes. His current research interests include ultrafast laser applications, biomedical optics, precision engineering, and nanomanufacturing. Dr. Chen is a Fellow of Optica (formerly OSA), Fellow of American Society of Mechanical Engineers (ASME), senior member of SPIE, and members of the American Society for Precision Engineering (ASPE) and Hong Kong Young Academy of Sciences (YASHK). He currently serves as the Associate Editor of ASME Journal of Micro- and Nano-Manufacturing, IEEE Transactions on Nanotechnology, and HKIE Transactions. In 2003 and 2018, he received the prestigious R&D 100 Awards for developing a six-axis nanopositioner and an ultrafast nanoscale 3D printer respectively.

Abstract

There has been a compelling demand of fabricating high-resolution complex 3D structures in various engineering fields. While two-photon lithography (TPL) largely satisfies the need since its introduction, its low writing speed and high cost make it impractical for many large-scale applications. On the other hand, TPL often requires multiple trial and errors steps to identify the optimal parameters with limited reproducibility. In this seminar, I will present a digital holography-based TPL platform that realizes parallel printing with up to 2000 individually programmable laser foci to fabricate complex 3D structures with a minimum feature size of 90 nm. This effectively improves the fabrication rate to 2,000,000 voxels/sec. The promising result is enabled by the polymerization kinetics under a low-repetition-rate regenerative laser amplifier, where the smallest features are defined via a single laser pulse at 1 kHz. To improve the reproducibility of TPL, a high-speed metrology system is developed based on optical diffraction tomography and integrated with the TPL platform to monitor the 3D refractive index as well as laser doses of the printed part in situ at 300 Hz in. The precision, rate, and reproducibility of the new TPL platform were verified by the fabrication of large-scale metastructures and optical devices of up to centimeter-scale. Our new methods provide an effective and low-cost solution to scale-up the fabrication of functional micro- and nano-structures, enabling TPL for industry-scale applications.

Advancing Towards the Fabrication and Implementation of Freeform Optics

Xiaodong Zhang
School of Precision Instrument and Optoelectronics Engineering
Tianjin University

Biography

Xiaodong Zhang has been deeply engaged in researching and developing ultra-precision manufacturing techniques and ultra-precision/precision optical testing methodologies for optical freeform surfaces. His scholarly contributions include 103 papers published in reputable SCI journals, and he holds 80 national invention patents. He has been recognized as a part of the inaugural cohort of young scientific and technological talents under the Tianjin Innovation Talent Promotion Plan. His accomplishments have been further celebrated with the prestigious Tianjin Science and Technology Progress Special Award, the "Young Researcher Award" by the Asian Society for Precision Engineering and Nanotechnology (ASPEN), among other distinguished awards. He also holds a fellowship with the International Society for Nanomanufacturing (ISNM), underscoring his influential standing in the field.

Abstract

Freeform optics offer appealing attributes such as flexible design, lack of rotational symmetry, and complex analytical expression. These optics are typically large in size and demand precision in both surface accuracy and quality. Producing freeform optics involves designing, manufacturing, measuring, and evaluating. Over the past ten years, the manufacturing technology for freeform optics has advanced rapidly, leading to increasingly demanding requirements for their production and application. Within this realm, various processing methods have emerged, necessitating greater focus on innovative techniques such as fast tool servo turning, flying cutting, and integrated machining. These cutting-edge approaches enable the production of multi-surface freeform optics through the coordinated movement of cutting tools across multiple axes. However, In the manufacturing process of freeform optics, greater attention should be given to the interaction between the processing tool and the workpiece surface, drawing from materials science and kinematics. Additionally, the role of measurement in processing has grown in significance. Developing comprehensive measurement systems integrating all processing times and spaces will greatly improve processing accuracy and quality. Freeform optics have found applications in diverse industries such as short-focus projection, AR/VR, laser scanning, and laser radar, with room for further expansion into various optical-related aspects of daily life. However, challenges persist in system assembly due to the lack of reference for modeling or positioning, limiting the use of freeform optics in advanced optical systems. Currently, assembly relies heavily on human experience and subjective judgment, leading to high installation costs and resource requirements. Automated installation and adjustment, an emerging technology spanning optical design, mechanical automation, and computer artificial intelligence, offers a promising solution by guiding optical component installation through final performance evaluation. This approach opens up broader application possibilities for freeform optics in optical systems and enhances their adaptability.

Freeform Phase Plate in Filament-induced Fluorescence Spectroscopy (FIFS) System

Xing Zhao
College of Electronic Information and Optical Engineering
Nankai University

Biography

Professor Xing Zhao, received his PhD degree in Optics Engineering from the Institute of Modern Optics, Nankai University in 2007. After that, he joint Nankai University as lecture, associate professor and professor. He visited and worked in Advanced Optics Manufacturing Center, the Hong Kong Polytechnic University in 2014. His current research interests are concerned with computational imaging and freeform optics. In last decade, he published more than 60 peer-reviewed journal articles and had 6 authorized patents. He has won two Scientific and Technological Progress Award (First Class) as co-contributor.

Abstract

High power ultrafast femtosecond laser will form a unique plasma channel at the beam focus due to the nonlinear effect when propagating in the transparent optical medium, called as "filamentation". Filament-induced fluorescence spectroscopy (FIFS) is a technique using filamentation as the excitation source of fluorescence spectrum for detecting material components, which has important application value in monitoring atmospheric pollutants. However, when adopting the optical system to remotely focus femtosecond laser into filament, due to the aberration in the system, the shape of the focused beam spot is irregular, the radius increases, and the quality decreases. These will weaken the intensity of the filamentation, reduce the detection sensitivity of the system, and is not conducive to remotely detect the atmospheric pollutants with low concentration. Combined with the strong aberration compensation ability of optical freeform surface, we propose a method to introduce a transmission freeform surface phase plate into the FIFS system to compensate the system aberration. In our research, the freeform phase plate is designed, optimized and manufactured successfully. Moreover, the femtosecond laser filamentation system with freeform surface phase plate is adjusted and the laser filamentation experiment is carried out. The experimental results demonstrate the effectiveness of the freeform surface phase plate, with the shape regularity of the focusing spot improved and the radius significantly reduced. The intensity of femtosecond laser filament is greatly enhanced, as well. Our research results indicate that it is feasible to use optical freeform surfaces to compensate the aberration in the FIFS system, which is of great practical value for enhancing the intensity of femtosecond laser filamentation at a long distance and improving its remote sensing detection sensitivity.

Invited Talks

Research on Double-sided Lapping of Thin Copper Plate with Weak Rigidity

Jiang Guo
State Key Laboratory of High-performance Precision Manufacturing
Dalian University of Technology

Biography

Prof. Jiang Guo is currently a professor at the Dalian University of Technology (DUT), and received his Ph.D. from The University of Tokyo in 2013. After graduation, he joined RIKEN as a researcher. In October 2015, Prof. Guo became a scientist at A*STAR (Agency for Science, Technology and Research). His research areas include precision/ultra-precision machining, optical manufacturing, and metal substrate additive forging, etc. He presided over 20 projects, including the National Natural Science Foundation of China, the National Key Research and Development Program, and the Japan Society for the Promotion of Science (JSPS) Youth Fund. Throughout his career, Prof. Guo has authored 100+ peer-reviewed journal papers in the top journals and holds 60+ international and national invention patents. In 2022, he was selected as one of the world's top 2% scientists at Elsevier. He has won more than 10 academic awards, such as the Second Prize of Science and Technology Progress of Machinery Industry Science and Technology in 2023, the Revitalization Award of the Japan Machine Tool Promotion Association, and the Outstanding Research Achievement Award of the Chinese Students Association in Japan. Prof. Guo is currently a senior member of the Chinese Mechanical Engineering Society, a member of the European Society for Precision Engineering and Nanotechnology (EUSPEN), the American Society for Precision Engineering (ASPE) and the Asian Society for Precision Engineering and Nanotechnology (ASPEN), etc.

Abstract

Pure metal thin plates have been widely used in precision physics experiments, which requires high accuracy, especially in terms of flatness and parallelism. Double-sided lapping is a widely used method for processing thin flat components, due to its low processing stress and high efficiency. This report focuses on examining the double-sided lapping of thin copper plates with weak rigidity. Firstly, the influence mechanism of the residual stresses relaxation on workpiece deformation during material removal is clarified. Based on these analyses, double-sided lapping process with fixed abrasive pads is proposed for machining pure copper thin flat plates. The workpiece deformation caused by the relaxation of internal residual stresses is improved by the same material removal from both sides simultaneously. Besides, this report systematically investigates the formation mechanism and evolution of the workpiece surface profile, strategies for controlling flatness and parallelism for the double-sided lapping process. Furthermore, a non-contact parallelism measurement method and device for large-sized non-transparent components are developed to meet the demands of measuring the parallelism of pure copper thin flat plates. Finally, a flatness of 2 μm and a parallelism of 2.6 μm were achieved on pure copper thin plates of Φ200 mm×2 mm.

Surface Reaction Kinetics for Selective Atomic Layer Deposition

Rong Chen
School of Mechanical Science and Engineering
Huazhong University of Science and Technology

Biography

Professor Chen is a full professor at Huazhong University of Science and Technology with the School of Mechanical Science and Engineering, by courtesy of School of integrated circuits, optical and electronic information, China-EU Institute for clean and renewable energy of HUST, and college of future technologies. She received her M.Sc. and Ph.D. degrees from Stanford, B.S. from University of Science and Technology of China.
She was a senior research scientist at Intel Labs before she joined HUST. Her research focuses on atomic layer deposition in ACSM, by understanding surface science, and applying this knowledge to a range of problems in sustainable energy, semiconductor processing, and nanotechnology.

Abstract

The underlying principals and mechanisms enabling selective atomic layer depositions are gaining rapid growing interests, which have unlocked attractive avenues for build nanostructures by placing atoms at desired surface locations. It has not only found versatile applications in semiconductor industry, but also in various emerging fields. In this talk, selective atomic layer deposition processes will be discussed from facet-selective ALD processes based on intrinsic differences of precursors chemisorption on terraces or step edges of nanoparticles, to the surface property driven selective ALD on nanopatterns. Self-aligned stacking on Cu/SiO2 BEOL structures have been achieved without excessive mushroom growth at the edge and undesired nucleation defects on the Cu region. In addition, an anisotropic growth model with the dynamical competition of expansion and dissociation of the nucleus is proposed to nucleation delay are quantitively predicted and the model provides a practical method to evaluate the selectivity of ALD theoretically. It provides a new strategy for inherently selective ALD, which will expand the selective toolbox of nanofabrication for next-generation nanoelectronic applications.

Acceleration Feedback Control in Fast Tool Servo Freeform Machining

Xichun Luo
Centre for Precision Manufacturing
University of Strathclyde

Biography

Xichun Luo is a Professor in ultra precision manufacturing and technical director of Centre for Precision Manufacturing (CPM) at the University of Strathclyde (Glasgow). He is a Fellow of the International Society for Nanomanufacturing and an editor for Proceeding of IMechE Part C: Journal of Mechanical Engineering Science, Journal of Micromanufacturing and Mechanical Sciences. He is also a member of editorial board for Micromachines, Nanomanufacturing and Metrology and Chinese Journal of Mechanical Engineering. His research has been founded by the EPSRC, EC, Royal Society and Industry. His research interests include ultra precision machining brittle materials, freeform machining, precision motion control, hybrid micromachining and FIB nanomanufacturing, as evidenced by two books and more than 120 papers in peer-reviewed highly ranked journals. He chaired two IEEE International Conferences in Automation and Computing in 2014 and 2015. He won UK Institution of Mechanical Engineers (IMechE) 2015 Ludwig Mond Prize for his work in the application of digital technology in micro- and nano-manufacturing.

Abstract

Fast tool servo freeform machining is an important manufacturing technology for generation of ultra precision freeform or structured surfaces. However, it faces problems of insufficient stiffness with large depth of cut.

This talk will introduce an analytical model to reveal how much positioning errors are caused by the added sensor noises in acceleration feedback control and how the acceleration feedback technique changes the closed loop stiffness. It will compare the measured positioning error spectrum with those predicted by the model under different acceleration gains. It will further verify the proposed stiffness model through frequency response tests. Through the designed cutting trials the dynamic stiffness is found to be significantly improved by 5.6 folds within the acceleration sensor bandwidth, while the stiffness deteriorates at frequencies beyond the band width due to the low-pass characteristics in the acceleration loop. Finally, the effectiveness of the control approach in freeform machining several typical freeform ultra precision surfaces is demonstrated.

Laser-Based Process for Fabricating High Laser Damage Threshold Optics

Chaoyang Wei
Shanghai Institute of Optics and Mechanics,
Chinese Academy of Sciences

Biography

Chaoyang Wei is currently a Professor of Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS). His current research interests include computer controlled sub-aperture optical fabrication， laser polishing etc.

Abstract

Fused silica optics are commonly used in high-energy laser systems due to the high intrinsic damage threshold. However, laser-induced damage in fused silica optics has seriously limited the development of high-energy laser systems. The fundamental reason is that the processing defects introduced by the current contact grinding and polishing process are difficult to be completely removed, which greatly reduces the damage resistance of the optics. Here, we proposed a whole-light processing chain (including laser ablation, laser cleaning, laser polishing, and laser beam figuring) to fabricate high damage threshold and ultra-precision fused silica optics based on the principle of step-by-step removal of defects and step-by-step convergence of accuracy. Through this chain, the laser-induced damage threshold of the sample fabricated is 41% (0% probability) and 65.7% (100% probability) higher than those of the samples fabricated by the conventional processing chain. At the same time, full-spatial-frequency error convergence with nanoscale surfaces is achieved at negligible stress. This innovative whole-light processing chain provides a new direction for the fabrication of highly damage-resistant and ultra-precision fused silica optics for high-energy laser applications.

Tomography of Microstructure by Interferometric Microscopy

Zhishan Gao
School of Electronic and Optical Engineering
Nanjing University of Science and Technology

Biography

Prof. Zhishan Gao received his M.S. in optics from Changchun Institute of Optics and Fine Mechanics (CIOMP) in 1992, and Ph. D. in optical engineering from Nanjing University of Science and Technology (NJUST) in 2000. He was a senior visiting scholar at University of Stuttgart, Germany, and Virginia Polytechnic Institute and State University, USA, in 2008 and 2015, respectively. He currently is a senior Professor and leader of group of advanced optical design and precision optical instrument (AODPI) at NJUST with the department of Optical Engineering.
Prof. Gao's research interests center around optical design, and optical metrology. His research covers interferometry, optometry, optical design of freeform optics, binary optics, and et al. He received more than 20 Chinese patents; authored and co-authored 3 books and book chapters, more than 100 refereed papers; delivered more than 20 colloquium, seminars, invited conference presentations. He is a member of a council of the Chinese Optical Society (COS) and the Chinese Society for Optical Engineering (CSOE). He was awarded Wang Daheng's Optical Prize of the COS to commend and encourage his outstanding contribution made in optical science and technology in 2007. He is a chief scientist of National Key R&D Plan Project and National Major Instrument Project Manager.

Abstract

Micro structures act as sensitive form for many type sensors, which are widely used in the fields of MEMS, Trace Component Analysis, cooling parts and optical inspect of small target, et al. In the past, the form parameters of microstructure were usually tested by scanning electronical microscopy (SEM), but needs preparation of cutting sample, that is not suit to optimize the procession parameter. The low coherence microscopic interferometer is the non-destructive instrument of microstructure tomography. In this presentation, we talk about the feature of low coherence microscopic interferometer, the fundamental and experiment data of this instrument used to measure different kinds of microstructure, for example surface microstructure with height near to working wavelength, dense microstructure with cycle near to diffraction-limit of microscopy, and high aspect ratio microstructure. We also talk about advance in low coherence interferometer with big field of view.

In-process Measurement for Micro and Nano-scale Diamond Cutting

Yuanliu Chen
Institute of Precision Engineering and Micro/nano-Technology
Zhejiang University

Biography

Dr. Yuan-Liu Chen is the vice director and professor of the institute of precision engineering and micro/nano-technology, Zhejiang University, China. He is the Young Changjiang Scholar of the Ministry of Education since 2018. He received his Bachelor of Mechatronic Engineering from Zhejiang University, China, in 2009, followed by Ph. D co-trained by Zhejiang University of China and Tohoku University of Japan in 2014, respectively. After the Ph.D, Dr. Chen joined the Precision Nanometrology lab in Tohoku University of Japan as a postdoctor from October 2014 to April 2015 and became a Research Fellow from April 2015 supported by Japan Society for the Promotion of Science (JSPS). He was then appointed as an Associate Professor at Tohoku University since Oct. 2016. Since June 2018, he joined the department of mechanical engineering at Zhejiang University as a Professor.
Dr. Chen's research interests lie primarily in the field of precision engineering and metrology, ultra-precision manufacturing and surface engineering.

Abstract

Micro/nano-cutting by utilizing a single point diamond tool is an important technology for fabrication of micro-structured and freeform surfaces. A fast tool servo (FTS) is usually employed in micro/nano-cutting for obtaining micro/nano-structured surfaces with complex geometries. Since the FTS assisted micro/nano-cutting is a complicated process in which materials are removed fast by the sharp edge of a diamond tool, in order to evaluate the cutting quality, it is necessary to monitor the cutting status based on in-process measurement technologies.
This report introduces a variety of self-developed FTS technologies with integrated force sensing functions, including smart tooling system with self-sensing of cutting temperature, force sensing piezoelectric FTS, force self-sensing electromagnetic driven FTS, and force servo cutting based on deformation of flexible mechanism. These technologies meet the needs of accurate process sensing and servo control for micro and nano-scale diamond cutting. By combining with machine learning method, intelligent monitoring and perception of ultra-precision machining status is possible.

A Cooperative Rotary Servo Indenting Technology for Flexible Machining Micro-structured Surfaces

Zhanwen Sun
State Key Laboratory of Precision Electronic Manufacturing Technology and Equipment
School of Electromechanical Engineering
Guangdong University of Technology

Biography

Dr. Zhanwen Sun graduated from the State Key Laboratory of Ultra-precision Machining Technology of the Hong Kong Polytechnic University with a PhD degree, under the supervision of Prof. Suet To (Deputy Director of the State Key Laboratory). He has studied and worked in the Key Laboratory of Advanced Manufacturing Technology in Shenzhen of the Harbin Institute of Technology (Shenzhen), and is now employed as a associate professor of the School of Mechanical and Electrical Engineering of Guangdong University of Technology, a young editorial committee member of the journal Diamond and Abrasive Engineering, and a young member of the Chinese Optical Engineering Society. He has published manufacturing field mainstream SCI journal papers more than 20, participated in the publication of Springer book 2, presided over projects including the National Natural Science Foundation of China, Guangdong Province Natural Science Foundation project. He has served as a reviewer for SCI journals in the field of manufacturing, such as Optics Express, International Journal of Machine Tools and Manufacture, Journal of Materials Processing Technology, Applied Optics, and Journal of Manufacturing Processes. His research works are in the field of manufacturing, mainly engaged in the processing of semiconductor materials, ultra-precision machining of optical components, design of micro-nano positioning platforms, cutting mechanism of difficult-to-machine materials and other directions of research work.

Abstract

To achieve flexible fabrication of microstructured surfaces or anti-counterfeiting micro-images on metal alloys, this study proposes a cooperative rotary servo indenting (CRSI) system by integrating a uniaxial fast servo motion (FSM) platform into multi-axis rotary servo indenting system. In CRSI, the rotary servo indenting system is used to fabricate inverted pyramid micro-pits with different orientation angles, to represent the pixels with different grayscale values and security codes. Meanwhile, the FSM platform cooperatively moves according to the feed distance of Z guideway to compensate the material spring back errors, in which way the visual grayness deviation of each pixel can be corrected. To determine the optimum compensating distance of FSM, a simplified spring back error model is proposed by considering subsurface strain-stress distribution of workpiece material. The tool path planning algorithm of the CRSI system is proposed to fabricate desired micro-images with deliberately designed security codes. A piezoelectrically actuated quadruple parallelogram flexure mechanism is also designed for the FSM platform to fulfil the requirement of stroke and working bandwidth. The proposed CRSI approach is experimentally validated by machining the famous "Mona Lisa Smile" image on Ti6Al4V alloy with the security code π, and the three-dimensional morphology of the pixel micro-pits are measured to validate the spring back error compensation strategy and the anti-counterfeiting strategy. The results demonstrate that the proposed CRSI can efficient fabrication of complex micro-images with hidden security codes on titanium alloys with high form accuracy and sharpness.

Surface Finishing of X-Ray Crystal Optical Elements by PCVM (Plasma Chemical Vaporization Machining)

Yasuhisa Sano
Graduate School of Engineering
Osaka University

Biography

Prof. Yasuhisa Sano is currently an Associate Professor at the Department of Precision Engineering of Osaka University. He started his academic career as an Assistant Professor in 1993 and obtained a Doctor of Philosophy in Engineering from Osaka University in 2002. He has also been a visiting scientist at RIKEN since 2001. He has consistently been engaged in the development of novel processing methods based on chemical reactions and their applications to various damage-free processing of single crystal semiconductor substrates such as silicon, silicon carbide, gallium nitride, gallium oxide, and diamond and finishing of high-precision x-ray crystal optical elements. He is a member of JSPE and JSAP, and also an executive committee at JSAP Advanced Power Semiconductors Division, JSAP Industry-academia collaboration committee on semiconductor crystal growth, processing and characterization, JSPE The Planarization and CMP Technical Committee, and JSPE Ultra Precision Technical Committee.

Abstract

X-ray crystal optical elements are elements that utilize Bragg diffraction and can select specific wavelengths from broad synchrotron radiation or reflect monochromatized X-rays in specific directions, and are indispensable optical elements in synchrotron radiation facilities and X-ray free electron laser facilities. The presence of a damaged layer on the X-ray reflective surface of these optical elements can cause uneven intensity of reflected light and bring about a decrease in reflectance due to the disorder of the crystal lattice plane.
If the shape is a simple rectangular block, conventional high-precision polishing methods such as CMP (Chemical Mechanical Polishing) can be used to remove the damaged layer on the surface. However, it is difficult to remove the damaged layer in intricate geometries such as channel-cut crystal monochromators (CCMs), which use the inner walls of a rectangular groove formed on a single crystal block as a reflective surface, because conventional high-precision polishing methods cannot be applied to such surface. We have proposed to remove the damaged layer on the x-ray reflective surface of such crystal optical elements using PCVM (Plasma Chemical Vaporization Machining), a chemical etching technique using atmospheric pressure plasma. In this presentation, I will introduce an overview of this technique with some practical examples.

Automated Design and Fabrication of Freeform Micro-lens-arrays

Anthony Beaucamp
Department of System Design Engineering
Keio University

Biography

Associate Professor Anthony Beaucamp is an active contributor to the international community for ultra-precision engineering. After working 10 years in the optical fabrication industry at Zeeko Ltd (UK), he initiated an academic career in 2010 by joining the laboratory for EUV and X-Ray optics of Prof. Namba at Chubu University (Japan). Since 2015, he has been an Associate Professor first at Kyoto University and now Keio University (Japan).
His current research topics cover digital design and manufacture (generative design, digital twins, machine learning), multi-scale modelling of fine abrasive processes, and development of hybrid machining systems based on focused ultrasound and non-Newtonian fluids.
With 10 international patents (granted and pending), more than 100 publications (>50 in peer-reviewed journals), Dr. Beaucamp has an established track-record in ultra-precision manufacture that was recognized by the award of the F. W. Taylor medal of CIRP in 2015, for contributions to super-fine finishing technology.
https://www.scopus.com/authid/detail.uri?authorId=6507185016

Abstract

Micro-lens-arrays (MLAs) typically consist of a glass plate or mirror surface onto which a repeating pattern of identical micro-lenses has been machined or etched. While these "first generation MLAs" have found a number of uses in areas such a light-field microscopy and light homogenization, their adoption remains rather limited to niche applications.
In this presentation, the concept of "second generation MLAs" with non-repeating arrangements of freeform surfaces is introduced. Advanced methods for their automated design and fabrication will be provided, together with an overview of their potential for wide-range application in photonics.

Ultrasonic Micro/nano Manufacturing

Jianjian Wang
Department of Mechanical Engineering
Tsinghua University

Biography

Dr. WANG Jianjian is from Department of Mechanical Engineering, Tsinghua University Beijing, China. Dr. Wang's research activities are focused on vibration enhanced/enabled manufacturing processes. Dr. Wang has published more than 50 peer reviewed papers, including Small, International Journal of Machine tools and Manufacture, Journal of Material Processing Technology etc. He was a Humboldt Research Fellow in Germany. He received grants from Science Fund Program for Distinguished Young Scholars (Overseas), China, etc.

Abstract

The micro-nano functional structures on metal surfaces can impart specific optical, thermal, and chemical interface properties to objects. They are an effective means for engineering surface performance and functional control, holding broad application prospects in strategic areas such as energy and the environment, biomedicine, aerospace, national defense, and intelligent manufacturing. In recent years, to meet the application demands in these strategic fields, the development trend of metal surface functional structures has evolved towards multi-dimensionality, multi-scale, large-area, and spatially curved surfaces, posing new challenges to current micro-nano manufacturing capabilities. The fundamental principle of ultrasonic micro-nano processing is essentially the removal of material using force pulses under conditions far from equilibrium, efficiently creating microstructures while minimizing unnecessary processing damage to the material's interior. In the processing of multi-scale optical-thermal functional structures, ultrasonic micro-nano processing has demonstrated excellent process capabilities. As a mechanical processing method, its fundamental advantage lies in its outstanding geometric shape control ability. Furthermore, ultrasonic processing easily integrates with technologies like robotics, naturally possessing the capability to manufacture large-area and spatially curved functional structures. In summary, ultrasonic processing stands out with distinct features and clear advantages, holding significant application potential in the efficient and controllable manufacturing of metal surface functional structures.

Gravity-assisted Hot Embossing for Producing High-quality Glass Micro/nanostructures

Feng Gong
Shenzhen Key Laboratory of High-performance Nontraditional Manufacturing
College of Mechatronics and Control Engineering
Shenzhen University

Biography

Prof. Feng GONG is the Vice Dean of the College of Mechatronics and Control Engineering at Shenzhen University, the Director of Shenzhen Key Laboratory of High-Performance and Nontraditional Manufacturing, the Vice Chairman of the Mold and Forging Engineering Branch of the Guangdong Mechanical Engineering Society, the Executive Committee Member of the Advanced Optical Manufacturing Youth Expert Committee of the China Optical Engineering Society. He is mainly engaged in advanced optical manufacturing processes and equipment, nontraditional plastic forming processes and theories. He has hosted projects such as the National Natural Science Foundation of China, Natural Science Foundation of Guangdong Province, and the Shenzhen Hong Kong Joint Funding Program. He received one second prize in Guangdong Province Science and Technology Progress Award as the first author, published more than 40 SCI indexed academic papers as the first author or corresponding author, and authorized more than 10 Chinese invention patents.

Abstract

Glass micro/nanostructures, such as micro/nano optical components, micro-opto-electro-mechanical systems, and micro fluidics have advantages of miniaturization, integration, high sensitivity, and low energy consumption, and are thus applied in the new generation of optical systems, informatics, mechatronics, and biochemistry. Owing to the high replication accuracy, high production efficiency, and environmental friendliness, hot embossing has become a promising technology for mass production of glass micro/nanostructures. This study developed a novel two-stage gravity-assisted hot embossing machine and proposed a forming process for the production of high-quality N-BK7 glass micro-pillar array. In this approach, the two-stage gravity loading unit provides accurate force on glass preform through a simple control system, and the tailor-made heating module based on Si3N4 ceramic heaters requires an energy consumption of just 700 kJ per molding cycle. As a result, it is featured by low energy consumption and high manufacturing efficiency. In this study, the effects of the embossing temperature, force, and time on the replication accuracy of a K9 glass micro-pillar array were investigated through a series of hot embossing experiments. Afterward, the form accuracy, uniformity of microstructures, and warpage of glass replicas under the optimal process parameters were evaluated separately. Finally, repeated hot embossing experiments were conducted to demonstrate the reproducibility of the hot embossing process. The experimental results show that embossing temperature had the most significant effect on the replication accuracy of glass micro-pillars. By optimizing the process parameters, the embossed glass micro-pillars could achieve transfer ratios of 99.00% and 95.14% in height and diameter, respectively. Moreover, the surface roughness of glass micro-pillars was less than 5 nm, and the warpage amplitude of glass replicas in a 3.9 × 3.9 mm area was smaller than 1 μm. The small discrepancy in geometric features of glass replica in the repeated trails reflects the satisfactory reproducibility of this hot embossing process on the micro and nano scales. The results indicate the strong industrialization potential of the proposed two-stage gravity-assisted hot embossing machine and hot embossing process for fabricating high-quality glass microstructures more cleanly and sustainably.

Grits Texturing and Grinding Performance of Brazed Diamond Wheel

Quanli Zhang
College of Mechanical and Electrical Engineering
Nanjing University of Aeronautics and Astronautics

Biography

Dr. ZHANG Quanli is from College of Mechanical and Electrical Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing, China. Dr. ZHANG's research activities are focused on laser precision machining and ultra-precision grinding of hard and brittle materials.

Abstract

With the advantages of high grit protrusion, strong grit bond strength and high grinding ratio, the brazed diamond grinding wheel with orderly arranged abrasive grains shows extraordinary ability in processing of hard and brittle materials. However, the brazing technology are limited to fabricate the medium or large size of orderly arranged abrasives wheels, where the production advantages of fine grits or micro-powder particle brazed grinding wheels for precision/ultra-precision machining of hard and brittle materials becomes dull. The nonuniform grains protrusion of brazed diamond grinding wheel makes it difficult to be applied in the precision machining of hard and brittle materials. At present, the low dressing accuracy, serious abrasive particle breakage, rapid wear of dressing tools and long dressing time still exist, which make efficient and precise dressing of brazed diamond grinding wheel a great challenge to improve the surface quality of hard and brittle materials. Therefore, the design and laser texturing of abrasive grits for the brazed diamond wheel are proposed to solve the problems in precision and high efficiency grinding of cemented carbide, from the perspective of improving the dressing efficiency and quality of brazed diamond grinding wheel to control the material removal mode and improve the obtained surface quality, where the ablation mechanism and low damage machining of surface texture on diamond, the grits texturing of the brazed diamond grinding wheel and the grinding performance of abrasive grits textured brazed diamond wheel are mainly involved.

Highly Efficient Figuring of X-Ray Mirrors Using a Jet Type Atmosphere Plasma

Hui Deng
Department of Mechanical and Energy Engineering
Southern University of Science and Technology

Biography

Dr. Deng obtained his bachelor's degree in mechanical engineering from Huazhong University of Science and Technology in 2010. Then he studied in Osaka University, Japan and obtained the master and Ph.D. degree in precision science and technology in 2013 and 2016 respectively. After graduation, he joined Singapore Institute of Manufacturing Technology (SIMTech) as a research scientist. In 2017, Dr. Deng joined Southern University of Science and Technology and established the Advanced Plasma Manufacturing Lab. His research interest is focusing on plasma-based atomic-scale manufacturing.

Abstract

Si-based X-ray mirrors with atomic level roughness and nanometer level form accuracy are strongly required by some synchrotron radiation facilities. Usually the X-ray mirrors are fabricated by ion beam figuring (IBF) of abrasive finishing. To realize the highly efficient and damage-free manufacturing of high quality X-ray mirrors, a hybrid process combining jet plasma figuring and resin polishing was proposed. It reveals that the jet plasma has a very high material removal rate (MRR) of 0.14 mm3/min, which is more 100 times larger than that of IBF. For a small planar X-ray mirror (100×50 mm), the RMS was reduced from 1.01 μm to 89.4 nm after three rounds of jet plasma figuring. This work demonstrates that the jet plasma is promising approach for highly efficient manufacturing of X-ray optics.

Advanced Laser Manufacturing for Interdisciplinary Applications

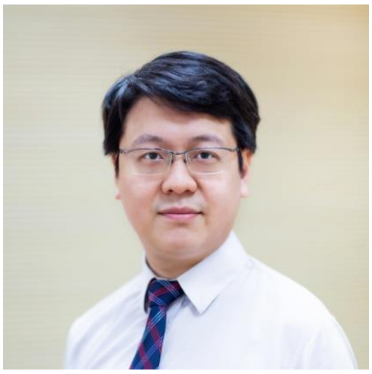
Mitch Guijun Li
Center for Smart Manufacturing
The Hong Kong University of Science and Technology

Biography

Mitch Li received his B.Sc. degree in Physics from Nanjing University and his Ph.D. degree in Electrical and Electronic Engineering from the University of Hong Kong. After graduation, he worked at the University of Hong Kong (HKU) and Hong Kong Polytechnic University (PolyU), and joined the Hong Kong University of Science and Technology (HKUST) in 2020 as an Assistant Professor in the Division of Integrative Systems and Design.

Abstract

Emerging advanced laser technology develops from fundamental research to interdisciplinary applications. As fundamental components of laser, the photons carry both thermal effects and momentum. The laser will influence the material properties and tune their performance in many aspects. We will introduce our recent research for interdisciplinary areas, including healthcare, energy, and environment.



Surface Treatment Methods for Dental Zirconia

Kit Hon James Tsoi
Applied Oral Science & Community Dental Care
The University of Hong Kong

Biography

Dr James Tsoi is an Associate Professor in Dental Materials Science and Assistant Dean (Innovation) at HKU Faculty of Dentistry. He received BSc in Applied and Analytical Chemistry and PhD in Dental Materials Science, from the University of Hong Kong. He also holds the Memberships of Royal Society of Chemistry (MRSC) and British Computer Society (MBCS), and Fellow in Advanced HE (FHEA).
James is actively engaged in a number of research areas including: Dental materials science (mechanical behaviours, surface/bonding and ceramics), biomaterials (scaffold), digital dentistry (CAD/CAM and AI) and dental education (basic science and e-learning). He has authored more than 130 peer-reviewed journal articles, graduated 36 MSc and 11 PhDs, and been awarded 8 times in international conferences since he joined as a HKU Dentistry member in 2012. He is currently serving on the editorial boards of several SCI journals (including Dental Materials) , being Vice-President in IADR-Dental Materials Group, Member-at-large in the Academy of Dental Materials, and Hong Kong head-of-delegate in ISO/TC 106 (Dentistry).

Abstract

Dental Zirconia is one of the most commonly used materials in prosthetic dentistry, ranges the application of dental crown, in/onlay, bridge, denture, veneer, implant and so on. In particular, they are not single phase polycrystal but utilize a mixture of phases so that it can be milled together with good optical and aesthetic properties. To deal with the variety of applications, polishing and roughening are necessary. In this talk, various surface treatment methods for the multi-phased dental zirconia will be discussed, and these surface treatment methods would ultimately affect the clinical outcome.

Digital Lensless Holographic Microscopy for Optical Metrology

Liangcai Cao
Department of Precision Instrument
Tsinghua University

Biography

Liangcai Cao received his BS/MS and PhD degrees from Harbin Institute of Technology and Tsinghua University, in 1999/2001 and 2005, respectively. Then he became an assistant professor at the Department of Precision Instruments, Tsinghua University. He is now tenured professor and director of the Institute of Opto-electronic Engineering, Tsinghua University. He was a visiting scholar at UC Santa Cruz and MIT in 2009 and 2014, respectively. His research interests are holographic imaging and holographic display. He is a Fellow of the Optica and the SPIE.

Abstract

Holography is a powerful technique that records the amplitude and phase of an optical field simultaneously, enabling quantitative analysis of optical waves and revealing the intricate interactions between light and physical objects. Lensless holographic microscopy features a large field of view, high spatial resolution, extended depth of field, as well as a compact and portable setup. However, the inherent ill-posed nature of holographic reconstruction presents technical challenges for quantitative evaluation. This presentation will discuss the recent advancements in using compressive sensing algorithms to achieve high-fidelity holographic imaging for metrological applications.

Conference Program

Conference Program

Day 1, 22nd Nov 2023 (Wednesday)

Venue: Hotel ICON 1/F, Silverbox Ballroom (Registration: 08:15-08:30)	
08:30-08:45	<u>**Opening Ceremony**</u> **Welcoming address by** 1. **Yu Hang Christopher Chao,** *Vice President (Research and Innovation), The Hong Kong Polytechnic University* 2. **Fengzhou Fang,** *CIRP President, Tianjin University* 3. **Chi Fai Benny Cheung,** *ASPEN President, Conference Chair of ASPEN, Director of SKL-UPMT, The Hong Kong Polytechnic University*
Plenary Session I (Session Chair: Chi Fai Benny Cheung, The Hong Kong Polytechnic University)	
08:45-09:25	**Damage-free Finishing of Optical Crystal Surfaces by Means of Plasma Modification** *Fengzhou Fang,* Tianjin University
09:25-10:05	**Digital Transformation of Machining Process** *Dong Yoon Lee, Korea Institute of Industrial Technology*
Tea/coffee Break (10:05-10:30)	
Plenary Session II (Session Chair: Sandy To, The Hong Kong Polytechnic University)	
10:30-11:10	**A Study on the Development of a Smart Manufacturing Framework** *Senthil Kumar Anantharajan, National University of Singapore*
11:10-11:50	**Fabrication and Field Emission Characteristic of Carbon-based Nano Composite Materials** *Hung-Yin Tsai, National Tsing Hua University*
Lunch Break (11:50-13:30, Venue: Hotel ICON 1/F)	
13:00-14:00	**Industrial Session**
Plenary Session III (Session Chair: Wing Bun Rongbin Lee, The Hong Kong Polytechnic University)	
14:00-14:40	**From Precision to 'Precisions' – A Research Journey and the Lessons Learned** *Tien-Fu Lu, The University of Adelaide*
14:40-15:20	**Multiscale Manufacturing: from Structures to Functions** *Zuankai Wang, The Hong Kong Polytechnic University*
Tea/coffee Break (15:20-15:45)	
15:45-17:30	**Technical visit I (Venue: The Hong Kong Polytechnic University)** *Please register at the reception desk (Max. 80 people, on a first come, first served basis)*
17:30-19:30	**Young Researcher Networking** **Venue:** Tack Hsin Restaurant, 2/F, Peninsula Centre, No. 67 Mody Rd, Tsim Sha Tsui East

Oral Presentations

Day 2, 23rd Nov 2023 (Thursday), 08:30-10:30 (Abstracts on p.77)

Time	Micro/Nano Fabrication Processes (I) (Room 1)
Session Chairs:	Julong Yuan, Zhejiang University of Technology Jiang Guo, Dalian University of Technology
08:30-08:55	**Force Rheological Polishing Technology and Its Research Progress (Session Keynote)** *Julong Yuan*, Zhejiang University of Technology
08:55-09:15	**Research on Double-sided Lapping of Thin Copper Plate with Weak Rigidity (Invited Talk)** *Jiang Guo*, Dalian University of Technology
09:15-09:30	**Tool-wear-free Electrochemical Discharge Machining via Electrolyte Jet (ASPEN2023P_046)** *Yonghua Zhao and Jiajun Lu,* Southern University of Science and Technology
09:30-09:45	**Polishing of Ti_6Al_4V Internal Structures Made by Laser-based Powder Bed Fusion (ASPEN2023P_155)** *Mingyue Shen and Fengzhou Fang,* University College Dublin
09:45-10:00	**Increasing Removal Efficiency of Electrical Discharge Machining Using LC Pulse Generator (ASPEN2023P_083)** *Masanori Kunieda and Lin Jiang,* The University of Tokyo
10:00-10:15	**A Study on Tool Influence Function and Polished Surface Characteristics of Belt Polishing Spinel ($MgAl_2O_4$) (ASPEN2023P_065)** *Jianbo Zhao, Sheng Wang and Qingliang Zhao,* Harbin Institute of Technology
10:15-10:30	**Generation of Silicon Nanoparticles by Line-Focused Laser Irradiation on Waste Silicon Powders (ASPEN2023P_012)** *Daiki Nakano, Jiwang Yan,* Keio University

Time	Atomic and Close-to-atomic Scale Manufacturing (Room 2)
Session Chairs:	Renke Kang, Dalian University of Technology Rong Chen, Huazhong University of Science and Technology
08:30-08:55	**Micro/nanostructured Material Generation from Silicon Waste - toward Material Resource Sustainability in Ultraprecision Machining (Session Keynote)** *Jiwang Yan, Keio University*
08:55-09:15	**Surface Reaction Kinetics for Selective Atomic Layer Deposition (Invited Talk)** *Rong Chen,* Huazhong University of Science and Technology
09:15-09:30	**Exploring Pulsed Laser Modification and Ablation at Close-to-atomic Scale (ASPEN2023P_145)** *Haojie An, Jinshi Wang and Fengzhou Fang*,* Tianjin University
09:30-09:45	**Atomic Observation of Structural Evolution of Turning Aluminum Surface During Ion Beam Bombardment (ASPEN2023P_120)** *Chunyang Du*, Tao Lai, Xiaoqiang Peng, Shanyong Chen and Cheng Huang,* National University of Defense Technology
09:45-10:00	**Large-area Fabrication of Micro-grooves on Ferrous Metals by Ultrasonic Vibration-assisted Turning with Laser-modified CBN Tools (ASPEN2023P_045)** *Lin Zhang, Daichi Kitagawa, Tushar Meshram and Jiwang Yan*,* Changchun University of Technology
10:00-10:15	**Micro Grooving of PZT by Femtosecond Pulsed Laser Irradiation (ASPEN2023P_091)** *Rei Aoba, Yuka Yamamuro, Masashi Hiraoka, Takashi Hitomi and Jiwang Yan*,* Keio University
10:15-10:30	**A Microfluidic Step-emulsification Device with Nozzles Arrayed on a Slit (ASPEN2023P_084)** *Chunqi Zheng, Shuzo Masui, Yusuke Kanno and Takasi Nisisako*,* Tokyo Institute of Technology

Time	High Speed and Precision Machining (I) (Room 3)
Session Chairs:	Bi Zhang, Southern University of Science and Technology Xichun Luo, University of Strathclyde
08:30-08:55	**Surface Integrity of Ti_6Al_4V Subjected to High-speed Grinding (Session Keynote)** *Bi Zhang*, Southern University of Science and Technology
08:55-09:15	**Acceleration Feedback Control in Fast Tool Servo Freeform Machining (Invited Talk)** *Xichun Luo*, University of Strathclyde
09:15-09:30	**Experimental Study of Electrochemical-assisted Drilling of Optical Glass (ASPEN2023P_014)** *Tianhao Cheng and Wei Han**, Fudan University
09:30-09:45	**Electrochemical Mechanical Polishing of 4H-SiC by Polishing Pads with Through Holes (ASPEN2023P_186)** *Yang Zhao, Renke Kang, Yuewen Sun and Zhigang Dong**, Dalian University of Technology
09:45-10:00	**Machinability Improvement in Micro Milling AlN After Laser Chemical Milling (ASPEN2023P_157)** *Jiawei Liu, Ni Chen*, Yibo Jiang, Junyi Zhao and Ning He,* University of Aeronautics & Astronautics
10:00-10:15	**The Direct Measurement of Cutting Temperature in Micro Zone Using a Boron-doped Diamond Tool (ASPEN2023P_167)** *Shiquan Liu, Liang An and Yuan-Liu Chen**, Zhejiang University
10:15-10:30	**Fabrication of Functional Surface Using Water Jet Guided Laser Processing: Mechanism of Surface Structure Fabrication by Underwater Processing of the Workpiece (ASPEN2023P_032)** *Mayuko Osawa, Shoichi Ui, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi**, The University of Tokyo

Day 2, 23rd Nov 2023 (Thursday), 10:45-12:45 (Abstracts on p.83)

Time	Micro/Nano Fabrication Processes (II) (Room 1)
Session Chairs:	Zhigang Dong, Dalian University of Technology Chaoyang Wei, Shanghai Institute of Optics and Fine Mechanics
10:45-11:10	**Photoelectrochemical Mechanical Polishing (PECMP) Theory and Technology for GaN Substrates (Session Keynote)** *Zhigang Dong*, Dalian University of Technology
11:10-11:30	**Laser-based Process for Fabricating High Laser Damage Threshold Optics (Invited Talk)** *Chaoyang Wei*, Shanghai Institute of Optics and Fine Mechanics
11:30-11:45	**High-speed Observation of Cathode Phenomena in Electrical Discharge Machining (ASPEN2023P_085)** *Qi Li, Xiaodong Yang* and Masanori Kunieda,* Harbin Institute of Technology
11:45-12:00	**Prediction Model for Depth of Grain Refinement Layers on the Machined Surface of Carbon Steel Based on Dynamic Recrystallization (ASPEN2023P_141)** *Shuyao Liu, Xibin Wang, Zhibing Liu*, Hongtao Chen and Pai Wang,* Beijing Institute of Technology
12:00-12:15	**Investigation of Plasma Gas for Modifying Gallium Nitride in Plasma-assisted Polishing (ASPEN2023P_069)** *Yuya Ohnishi, Tong Tao, Rongyan Sun*, Yuji Ohkubo and Kazuya Yamamura,* Osaka University
12:15-12:30	**Experimental Study on the Effects of Vibration Behavior on SQUD (ASPEN2023P_043)** *Takaaki Yoshimura, Tomohisa Tanaka,* Tokyo Institute of Technology
12:30-12:45	**Effect of Ultra-precision Grinding of Sapphire on Polishing Performance (ASPEN2023P_062)** *Sheng Wang* and Qingliang Zhao,* Harbin Institute of Technology

Time	Metrology (I), IoT/AI/Big Data in Manufacturing (Room 2)
Session Chairs:	Yanlong Cao, Zhejiang University Zhishan Gao, Nanjing University of Science and Technology
10:45-11:10	**Comb-based Optical Frequency Synthesizer for Precision Metrology with 15-digit Accuracy (Session Keynote)** *Seung-Woo Kim*, Korea Advanced Institute of Science and Technology
11:10-11:30	**Metrology of Microstructure Tomography by Interferometric Microscopy (Invited Talk)** *Zhishan Gao*, Nanjing University of Science and Technology
11:30-11:50	**In-process Measurement for Micro and Nano-scale Diamond Cutting (Invited Talk)** *Yuanliu Chen*, Zhejiang University
11:50-12:05	**A Novel Single-microparticle Total Analysis System Driven by Optical Tweezers (ASPEN2023P_029)** *Ryohei Omine, Yushen Liu, Shuzo Masui, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi**, The University of Tokyo
12:05-12:20	**Image Treatment of Spatter Flight Phenomena for Porous Metallic Parts Using Powder Bed fusion (ASPEN2023P_059)** *Justin Lach*, Moju Zhao, Ryo Okawara, Hiroshi Yoshizaki, Masahiko Sairaiji, Masayuki Nakao and Keisuke Nagato*, The University of Tokyo
12:20-12:35	**Reducing Battery Temperature and Short Circuit Risk With AI-optimized Nanofluids-Mineral Oil Immersion Cooling (ASPEN2023P_021)** *Guan-Jhih Wu, Ya-Chi Ho, Yung-Jen Cheng, Tsai-Liang Wu and Chih-Ya Shen**, National Tsing Hua University
12:35-12:50	**Improvement of the Transient Levitation Response of a Magnetic Levitation System Using Hybrid Fuzzy and Artificial Neural Network Control (ASPEN2023P_102)** *Yupeng Zheng and Hyeong-Joon Ahn**, Soongsil University

Time	Manufacturing Systems and Machine Tools (Room 3)
Session Chairs:	Yongsheng Gao, The Hong Kong University of Science and Technology Zhanwen Sun, Guangdong University of Technology
10:45-11:10	**In-process Form Profile Optical Measurement under Coolant Condition (Session Keynote)** *Yongsheng Gao*, The Hong Kong University of Science and Technology
11:10-11:30	**A Cooperative Rotary Servo Indenting Technology for Flexible Machining Micro-structured Surfaces (Invited Talk)** *Zhanwen Sun*, Guangdong University of Technology
11:30-11:45	**Thermal Error Estimation of Machine Tools by Data-fit Models Based on Multi-point Temperature Sensor (ASPEN2023P_098)** *Shun Tanaka, Toru Kizaki, Yuta Teshima, Kenichi Tomita and Naohiko Sugita*, The University of Tokyo
11:45-12:00	**Visualization Experiment of Immersion Cooling for Battery Thermal Management System using Mineral Oil and Aluminum Nitride Nanofluids (ASPEN2023P_082)** *Ya-Chi Ho, Po-Chih Chen, En-Lan Hu, Tsai-Liang Wu, Cheng-Hsuan Lin and Da-Jeng Yao*, National Tsing Hua University
12:00-12:15	**Effect of Surface Processing of Co-28Cr-6Mo Alloy on Wear Behaviour of Ultra-high Molecular Weight Polyethylene in Artificial Joint (ASPEN2023P_015)** *Yoshitaka Nakanishi, Yukio Fujiwara and Yoshihiro Komohara*, Kumamoto University
12:15-12:30	**A New Geometric-error Synthesis Model Based on the Abbe Principle of a Three-axis Machine Tool (ASPEN2023P_024)** *Tao Lai, Xiaoqiang Peng, Chaoliang Guan, Chunyang Du, Shanyong Chen and Chen Huang*, National University of Defense Technology
12:30-12:45	**Temperature Dependency of Stiffness in Machine Tool Spindle Using Carbon Fiber Composite (ASPEN2023P_092)** *Daisuke Kono* and Yuki Nara*, Kyoto University

Day 2, 23rd Nov 2023 (Thursday), 13:45-16:00 (Abstracts on p.89)

Time	Micro/Nano Fabrication Processes (III) (Room 1)
Session Chairs:	Masanori Kunieda, The University of Tokyo Yasuhisa Sano, Osaka University
13:45-14:10	**Challenges In Electrochemical Machining (Session Keynote)** *Masanori Kunieda*, The University of Tokyo
14:10-14:30	**Surface Finishing of X-Ray Crystal Optical Elements by PCVM (Plasma Chemical Vaporization Machining) (Invited Talk)** *Yasuhisa Sano*, Osaka University
14:30-14:45	**Predicted of Grinding Forces in Ultrasonic Vibration Grinding of Fused Silica Glass Based on the Stochastic Distributed Abrasive Grits (ASPEN2023P_026)** *Cheng Huang, Chunyang Du, Tao Lai, Shanyong Chen, Xiaoqiang Peng and Ming Zhou,* National University of Defense Technology
14:45-15:00	**Simulation of Wire Electrode Temperature in Wire Electrical Discharge Machining Based on Temperature Measurement Results by Two-color Pyrometer with Optical Fiber (ASPEN2023P_095)** *Toshiki Hinata, Tomohiro Koyano, Tatsuaki Furumoto, Yohei Hashimoto and Mitsugu Yamaguchi,* Kanazawa University
15:00-15:15	**Bottom Cutting High-speed Edm Using Thin Plate Electrode (ASPEN2023P_033)** *Keisuke Takeuchi and Hideki Takezawa,* Kogakuin University
15:15-15:30	**Numerical Investigation on Ultrasonic Assisted Multi-grain Scratching of Silicon Carbide (ASPEN2023P_151)** *Zhongwang Wang, Renke Kang, Yan Bao, Yidan Wang, Yan Qin, Jiansong Sun and Zhigang Dong,* Dalian University of Technology
15:30-15:45	**An Approach Towards an Integrated Process Control for Vibropeening (ASPEN2023P_148) (Virtual)** *Abhay Gopinath and A. Senthil Kumar,* National University of Singapore
15:45-16:00	**New Insights into Stray Corrosion Suppression in Electrochemical Jet Machining (ASPEN2023P_050)** *Bangyan Dong, Weidong Liu and Yonghua Zhao*,* Southern University of Science and Technology

Time	Bio/ Optical/ Medical Manufacturing and Applications (I) | Automation, Mechatronics, and Robotics (Room 2)
Session Chairs:	Xuejun Zhang, Changchun Institute of Optics Fine Mechanics and Physics, Chinese Academy of Science Anthony Beaucamp, Keio University
13:45-14:10	**Evolution of Space Optical Systems: ----From Aspheres to Freeforms (Session Keynote)** *Xuejun Zhang, Changchun Institute of Optics Fine Mechanics and Physics,* Chinese Academy of Science
14:10-14:30	**Automated Design and Fabrication of Freeform Micro-lens-arrays (Invited Talk)** *Anthony Beaucamp*, Keio University
14:30-14:45	**Characterization of Damage Properties of Ultra-precision Machined KDP Crystals Under Intense Laser Irradiation (ASPEN2023P_149)** *Wenyu Ding, Linjie Zhao, Jian Cheng, Zhaoyang Yin, Qi Liu, Guang Chen, Hongqin Lei and Mingjun Chen,* Harbin Institute of Technology
14:45-15:00	**Bacteria-assisted Production System for Functional Nano- and Microstructures Made with Programmable Viruses (ASPEN2023P_005)** *Hayato Goto, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi,* The University of Tokyo
15:00-15:15	**Small Multi-legged Robots for Moving on Wall Surfaces and Its Evaluation System for Adsorption Mechanism with Negative Pressure (ASPEN2023P_004)** *Mitsutoshi Watanabe, Masato Mizukami, Naohiko Hanajima and Yoshinori Fujihira,* Muroran Insititute of Technology
15:15-15:30	**Pose Estimation of a Mobile Robot for Accurate Object Detection using Digital Twin and Bayesian Optimization (ASPEN2023P_080)** *Su-Young Park, Doyoun Kim, Seouhwon Yi and Sung-Hoon Ahn,* Seoul National University

15:30-15:45	**A Piezoelectric Stick-slip Manipulator for a Holonomic Precision Mobile Robot (ASPEN2023P_094)** *Ryosuke Kinoshita, Eiji Kusui, Hazumu Kusama, Yohei Tsukui, Rintaro Minegishi, Yuna Sugiyama, Yuta Sunohara, Chihiro Sekine and Ohmi Fuchiwaki,* Yokohama National University
15:45-16:00	**Lightweight Design Methods for Water Strider Micro-robot Using Artificial Intelligence (ASPEN2023P_129)** *Sora Komine, Daigo Misaki and Kenji Suzuki,* Kogakuin University

Time	Additive Manufacturing (I) (Room 3)
Session Chairs:	Hideki Aoyama, Keio University Xiewen Wen, The Hong Kong Polytecchnic University
13:45-14:10	**Fully Automated Additive Manufacturing Using Directed Energy Deposition (DED) (Session Keynote)** *Hideki Aoyama,* Keio University
14:10-14:25	**Feature Value Detection from High-speed Observation of Spatter for Prediction of Porosity in Metals Formed Using Powder Bed Fusion (ASPEN2023P_036)** *Ryo Okawara, Moju Zhao, Justin Lach, Hiroshi Yoshizaki, Masahiko Sairaiji, Masayuki Nakao and Keisuke Nagato,* The University of Tokyo
14:25-14:40	**Evaluating Particle Separation in A 3D-printed Deterministic Lateral Displacement Device (ASPEN2023P_096)** *Yeyi Tang, Guangchong Ji, Yusuke Kanno and Takasi Nisisako*,* Tokyo Institute of Technology
14:40-14:55	**Effect of Laser Conditions on Surface Morphology after Powder Bed Fusion (ASPEN2023P_078)** *Liwei Chen*, Masayuki Nakao and Keisuke Nagato,* The University of Tokyo
14:55-15:10	**Design of Chamber for Selective Laser Melting Based on Inert-gas Flow Simulation (ASPEN2023P_110)** *Yuki Fujiwara, Ryo Koike, Yasuhiro Kakinuma, Keiichi Yamazaki, Takanori Mori and Yoko Hirono,* Keio University
15:10-15:25	**Elucidation of Spatter Formation Mechanism with High-speed Observation of Melt Pool in Metal Powder Bed Fusion (ASPEN2023P_049)** *Hiroaki Suzuki, Moju Zhao, Yusuke Ito, Takumi Koike, Masayuki Nakao and Keisuke Nagato,* The University of Tokyo
15:25-15:40	**Ambient Vibration Conductance of FDM-printed PLA Components (ASPEN2023P_139) (Virtual)** *Vinodth Paniselvam and A. Senthil Kumar,* National University of Singapore
15:40-15:55	**Analysis of the Relationship between Process Parameters and Hardness for the Finishing Process by Wire Arc Additive Manufacturing Combined with the Fsb Tool of Austenitic Stainless Steel 316L (ASPEN2023P_153)** *Teerayut Cordkaew, Jun`Ichi Kaneko and Takeyuki Abe,* Saitama University

Day 2, 23rd Nov 2023 (Thursday), 16:15-18:15 (Abstracts on p.98)

Time	Micro/Nano Fabrication Processes (IV) (Room 1)
Session Chairs:	Jianfeng Xu, Huazhong University of Science and Technology Jianjian Wang, Tsinghua University
16:15-16:40	**In-situ Field Assisted Ultra-precision Machining: Theory, Technology and Equipment (Session Keynote)** *Jianfeng Xu,* Huazhong University of Science and Technology
16:40-17:00	**Ultrasonic Micro/nano Manufacturing (Invited Talk)** *Jianjian Wang,* Tsinghua University
17:00-17:15	**Femtosecond Laser Direct Writing Based Laser-induced Graphene (LIG) Formation on Woods for Smart Home Realization (ASPEN2023P_086)** *Han Ku Nam, Dongwook Yang, Tongmei Jing, Younggeun Lee, Young-Ryeul Kim, Truong-Son Dinh Le, Seung-Woo Kim and Young-Jin Kim,* Korea Advanced Institute of Science and Technology (KAIST)
17:15-17:30	**High-precision Acoustic Cell Sorting in BioMEMS (ASPEN2023P_130)** *Ye Ai,* Singapore University of Technology and Design

17:30-17:45	**Multiphysics Simulation of Micro Electrochemical Machining Including Circuit Analysis of Pulse Power Supply (ASPEN2023P_115)** *Tomohiro Koyano and Tatsuaki Furumoto,* Kanazawa University
17:45-18:00	**Development of Deep Etching Method by Atmospheric Pressure Plasma Jet (ASPEN2023P_008)** *Kenta Nakazawa and Futoshi Iwata,* Shizuoka University
18:00-18:15	**Research on Surface Integrity Evolution of Short Arc Assisted Milling of Superalloys (ASPEN2023P_158)** *Pai Wang, Yifan Bai, Wenxiang Zhao, Hongtao Chen, Zhibing Liu, Shuyao Liu,* Beijing Institute of Technology

Time	Metrology (II) (Room 2)
Session Chairs:	Seung-Woo Kim, Korea Advanced Institute of Science and Technology Liang-Chia Chen, National Taiwan University
16:15-16:40	**Accurate and Traceable Reference Nano Dimensional Metrology (Session Keynote) (Virtual)** *Gaoliang Dai, Kai Hahm, F rank Pohlenz, Jan Thiesler and Johannes Degenhardt,* Physikalisch Technische Bundesanstalt (PTB)
16:40-17:05	**Advancements in Optical Metrology for Next-generation Semiconductor Packaging (Session Keynote)** *Liang-Chia Chen,* National Taiwan University
17:05-17:20	**Development of X-Ray Fourier Ptychography Using a Mirror-based Achromatic X-Ray Microscope (ASPEN2023P_066)** *Toshiki Ito, Takato Inoue, Shinnosuke Kurimoto, Yuto Tanaka, Yoshiki Kohmura, Makina Yabashi and Satoshi Matsuyama,* Nagoya University
17:20-17:35	**Gas-cell Locked Frequency Sweeping Interferometry Achieving High-speed Absolute Displacement Measurement (ASPEN2023P_079)** Hsi-Hui Lin, Chen-Yu Liao and Liang-Chia Chen, National Taiwan University
17:35-17:50	**Robust Surface Imaging Method Based on Quantum Single Pixel Imaging (ASPEN2023P_076)** Elie Magnon, Osaka University
17:50-18:05	**Design of Gaze Estimation Model Based on Multiple Feature Fusion (ASPEN2023P_138)** Zhonghe Ren, Fengzhou Fang and Rui Niu, Tianjin University
18:05-18:20	**Automated Detection of Mediterranean Snail in Australia Agricultural Fields using Machine Vision (132)** Shi Zhao and Tien-Fu Lu*, The University of Adelaide

Time	Molding and Forming Technology (Room 3)
Session Chairs:	Zejia Zhao, Shenzhen University Lihua Li, Shenzhen Technology University
16:15-16:40	**Non-isothermal Hot Embossing of High Melting Point Glass Lens (Session Keynote)** *Lihua Li,* Shenzhen Technology University
16:40-17:00	**Gravity-assisted Hot Embossing for Producing High-quality Glass Micro/nanostructures (Invited Talk)** *Feng Gong,* Shenzhen University
17:00-17:15	**Heating Process Effects before Hot Water Treatment in Injection Molding Direct Joining (ASPEN2023P_099)** *Shuohan Wang*, Zhongqi Cui, Fuminobu Kimura and Yusuke Kajihara,* The University of Tokyo
17:15-17:30	**Development of Automatic Mold Repair System Using Directed Energy Deposition-automatic Detection of Cracks on Mold (ASPEN2023P_119)** *Kazuki Abe*, Ryo Koike and Hideki Aoyama,* Keio University
17:30-17:45	**Investigation on Fog Defect of Molded Glass Lens (ASPEN2023P_154)** *Guangyu Liu and Fengzhou Fang*,* Tianjin University
17:45-18:00	**Automatic Tuning of a Hyperparameter for Autonomous Parameter Exploration in Roll-to-roll Heating System (ASPEN2023P_093)** *Masaki Ito*, Ura Tessho, Kohei Nagai, Toru Takahashi, Kentaro Iribe, Masayuki Nakao and Keisuke Nagato,* The University of Tokyo

Day 3, 24th Nov 2023 (Friday), 08:30-09:10

Time	Plenary Keynote Speech (Room 1)
Session Chairs: Hideki Aoyama, Keio University	
08:30-09:10	**Prof. Kazuto Yamauchi, Osaka University** *Ultimate Condensation of X-Ray Free Electron Laser Down to Single Nanometer Size by Precision Mirror Devices*

Day 3, 24th Nov 2023 (Friday), 09:15-11:00 (Abstracts on p.104)

Time	Non-traditional Machining (I) (Room 1)
Session Chairs: Kui Liu, Singapore Institute of Manufacturing Technology (SIMTech) Quanli Zhang, Nanjing University of Aeronautics and Astronautics	
09:15-09:40	**Recent Development of Ultra-precision Machining for Optical Applications (Session Keynote)** Kui Liu, Singapore Institute of Manufacturing Technology
09:40-10:00	**Grits Texturing and Grinding Performance of Brazed Diamond Wheel (Invited Talk)** Quanli Zhang, Nanjing University of Aeronautics and Astronautics
10:00-10:15	**Parameters Optimization for Low Residual Strain and High Manufacturing Speed for Polypropylene Material during Laser Drilling (ASPEN2023P_168)** *Shih-Hao Lin, Chung-Wei Ku, Cheng-Lun Kan, Han-San Xie, Chao-Ching Ho and Ching-Yuan Chang,* National Taipei University of Technology
10:15-10:30	**High Precision Grinding of Large-aperture Aspherical Surface Based on Medium-low Frequency Error Suppression Method (ASPEN2023P_088)** *Guoyan Sun, Xiabin Ji*, Jiaoteng Ding, Hang Cheng and Jigong Zhang, Xi'an Institute of Optics and Precision Mechanics,* Chinese Academy of Science
10:30-10:45	**Study on Machining Quality of Aluminum Honeycomb in Ultrasonic Cutting by Straight-blade Knife (ASPEN2023P_188)** *Jiansong Sun, Mingyue Wang, Wei Xing, Pengfei Zhang, Zhiyao Li and Yidan Wang*,* Dalian University of Technology
10:45-11:00	**An Investigation on the Effects of Feature Size in High-frequency Ultrasonic Vibration-assisted Sculpturing of Microlens Array (ASPEN2023P_137)** *Canbin Zhang, Chi Fai Cheung*, Xiaoliang Liang and Benjamin Bulla,* The Hong Kong Polytechnic University

Time	Metrology (III) (Room 2)
Session Chairs: Shuming Yang, Xi'an Jiaotong University Mingjun Ren, Shanghai Jiao Tong University	
09:15-09:40	**Micro/nano Measurement Technology and the Application in IC (Session Keynote)** Shuming Yang, Xi'an Jiaotong University
09:40-09:55	**Development of Ultra-high Groove-density Grating by Ultrarapid Electron Beam Lithography for Full-field X-Ray Spectromicroscopy (ASPEN2023P_052)** *Kyota Yoshinaga, Yoko Takeo, Noboru Furuya, Kai Sakurai, Jordan T. O'neal, Satoru Egawa and Takashi Kimura,* The University of Tokyo
09:55-10:10	**Deep Groove Measurement Using Broadband Optical Frequency Comb Scattering Spectroscopy (ASPEN2023P_025)** *Satoshi Itakura, Tsutomu Ueohara, Yasuhiro Mizutani and Yasuhiro Takaya,* Osaka University
10:10-10:25	**Enhanced Measurement Technique for Lens Centering Error with Power Analysis and Subwavelength Grating-patterned Prism Module (ASPEN2023P_111)** *Yu-Zhen Mao, Chin-Ting Ho, Shiau-Cheng Shiu and Chun-Wei Liu,* National Tsing Hua University
10:25-10:40	**Performance Evaluation of On-machine Measurement Software (ASPEN2023P_030)** *Hibiki Tsubota, Ryosuke Kaji, Yukitoshi Ihara,* Osaka Institute of Technology
10:40-10:55	**A Broadband Spectrometer with Enhanced Spectral Resolution Using an Off-axis Elliptical Zone Plate (ASPEN2023P_104)** *Hyeokin Kang, Quang Huy Vu, Younggeun Lee, Young-Jin Kim and Joohyung Lee,* Seoul National University of Science and Technology

Time	High Speed and Precision Machining (II) (Room 3)
Session Chairs:	Jiwang Yan, Keio Univesrity Xusheng Yang, The Hong Kong Polytechnic University
09:15-09:40	**High Volume Replication of Micro and Nanoscale Optical Surface Structures (Session Keynote) (Virtual)** *Allen Yi*, The Ohio State University
09:40-09:55	**Bi-telecentric Phase Measurement Deflectometry for Optical Elements Quality Control (ASPEN2023P_144)** *Yingmo Wang, Fengzhou Fang,* Tianjin University
09:55-10:10	**Vibrational Monitoring and Analysis of Tool Wear Mechanism in High-speed Micro-grinding (ASPEN2023P_042)** *Yifu Liao, Jiahui Liu, Toru Kizaki, Keisuke Nagato, Masayuki Nakao and Naohiko Sugita,* The University of Tokyo
10:10-10:25	**Ultra-precision Machining of 95W-3.5Ni-1.5Fe Alloy by Ultrasonic Elliptical Vibratory Turning (ASPEN2023P_152)** *Hao Wang, Xiaoguang Guo, Shang Gao, Xianglong Zhu, Guolin Yang and Yan Bao,* Dalian University of Technology
10:25-10:40	**Fabrication of the Aspherical Mold Inserts by the Laser-assisted Turning (ASPEN2023P_160)** *Hanheng Du and Suet To,* The Hong Kong Polytechnic University
10:40-11:55	**Numerical and Experimental Investigation of the Form Maintainability of Structured Array Surfaces in Maskless Fluid Jet Polishing (ASPEN2023P_071)** *Zili Zhang, Chi Fai Cheung, Chunjin Wang and Jiang Guo,* The Hong Kong Polytechnic University

Day 3, 24th Nov 2023 (Friday), 11:15-13:00 (Abstracts on p.111)

Time	Non-traditional Machining (II) (Room 1)
Session Chairs:	Yung-Kang Shen, Taipei Medical University Hui Deng, Southern University of Science and Technology
11:15-11:40	**Surface Modification of Biomedical Metals by Femtosecond Laser (Session Keynote)** *Yung-Kang Shen*, Taipei Medical University
11:40-12:00	**Highly Efficient Figuring of X-Ray Mirrors Using a Jet Type Atmosphere Plasma (Invited Talk)** *Hui Deng*, Southern University of Science and Technology
12:00-12:15	**Fundamental Study on CO_2 Laser Forming of Carbon Fiber Reinforced Thermoplastic Sheet-relationship between Pulse Waveform and Forming Characteristics (ASPEN2023P_064)** *Ryoji Kitada, Sena Kizaki, Yasuhiro Okamoto and Akira Okada,* Sojo University
12:15-12:30	**Corrosion-resistant Coating Based on a Composite of Graphene Oxide and Flaky Zinc-rich Epoxy (ASPEN2023P_002)** *Tzu-Yu Huang, Po-Hung Cheng, Wei-Hsuan Hsu and Hung-Yin Tsai,* National Tsing Hua University
12:30-12:45	**A Hyper-viscoelastic Continuum Model for Preforming and Consolidation of Woven Carbon Fabric Reinforced Polymers (CFRPs) (ASPEN2023P_126)** *Deyong Sun and Weizhao Zhang,* The Chinese University of Hong Kong
12:45-13:00	**Piezo Flexure Mechanism for Extending Pulse Repetition Rate Control Range (ASPEN2023P_116)** *Woojeong Lee, Jungyoon Kim, Joohyung Lee, Seongheum Han, Seungman Kim and Jeongseok Oh,* Seoul National University of Science and Technology

Time	Metrology (IV) (Room 2)
Session Chairs:	Shanyong Chen, National University of Defense Technology Da Li, Nankai University
11:15-11:40	**Interferometric Testing and Alignment of Multiple Optical Surfaces Based on CGHs (Session Keynote)** *Shanyong Chen*, National University of Defense Technology

11:40-11:55	**Development of Composite Markers for High-precision Industrial 3D Inspection Systems (ASPEN2023P_070)** *Haochen Huang* and Daisuke Kono,* Kyoto University
11:55-12:10	**Surface Profile Error Evaluation Method of Machined Honeycomb Cores (ASPEN2023P_185)** *Yan Qin, Renke Kang, Wei Xing, Mingyue Wang, Pengfei Zhang, Zhiyao Li and Zhigang Dong*,* Dalian University of Technology
12:10-12:25	**Broadband Spectrum Generation Using IR-laser Pumped Laser-sustained Plasma (ASPEN2023P_106)** *Canh Doan and Joohyung Lee,* Seoul National University of Science and Technology
12:25-12:40	**Enhancing the Accuracy of Ultra-precision Straightness On-machine Measurements Based on Uncertainty Propagation Law (ASPEN2023P_192)** *Pu Huang, Jin Xie, Zhiguang Liu, Zhilin He, Xuancheng Huang and Shengyu Shi*,* South China University of Technology
12:40-12:55	**Interferometric Profiling of Wafer Surface Using Deep Learning and Two-frame Interferometry (ASPEN2023P_063)** *Jurim Jeon, Yangjin Kim* and Naohiko Sugita,* Pusan National University

Time	Additive Manufacturing (II) (Room 3)
Session Chairs:	Shih-Chi Chen, The Chinese University of Hong Kong Zibin Chen, The Hong Kong Polytechnic University
11:15-11:40	**Digital Holography-based Micro-additive Manufacturing (Session Keynote)** *Shih-Chi Chen,* The Chinese University of Hong Kong, Hong Kong
11:40-11:55	**Multi-objective Bayesian Optimization Method for High Strength and Dimensional Accuracy in Thermoplastic Extrusion Additive Manufacturing (ASPEN2023P_041)** *Hiroto Ikeda, Kota Aono, Masaki Ito, Masayuki Nakao and Keisuke Nagato,* The University of Tokyo
11:55-12:10	**Hybrid Finishing of the Additively Manufactured Tubular Lattice Structure for Medical Application (ASPEN2023P_081)** *Jiong Zhang, Ruochen Hong, Qianqian Nie and Hao Wang,* National University of Singapore
12:10-12:25	**Research on Mesoscale Modeling and Simulation of Selective Laser Melting Process of Quartz Powder (ASPEN2023P_010)** *Yating Qiu, Tian Yang and Wei Han,* Fudan University
12:25-12:40	**Investigation of Surface Roughness Effect on Machining Process of Workpieces Deposited by Wire and Arc Additive Manufacturing Method (ASPEN2023P_103)** *Gustavo Quadra Vieira Dos Santos, Jun`Ichi Kaneko and Takeyuki Abe,* Saitama University
12:40-12:55	**Improvement of Young's Modulus of the Structures Fabricated by Laser-assisted Electrophoretic Deposition (ASPEN2023P_006)** *Yuki Yoshimoto, Kenta Nakazawa, Makoto Ishikawa and Futoshi Iwata*,* Shizuoka University

Day 3, 24th Nov 2023 (Friday), 14:00-16:00 (Abstracts on p.117)

Time	Non-traditional Machining (III) (Room 1)
Session Chairs:	Huapan Xiao, The Hong Kong Polytechnic University Guijun Mitch Li, The Hong Kong University of Science and Technology
14:00-14:25	**Advancing Towards the Fabrication and Implementation of Freeform Optics (Virtual)** *Xiaodong Zhang,* Tianjin University
14:25-14:45	**Advanced Laser Manufacturing for Interdisciplinary Applications (Invited Talk)** *Guijun Mitch Li,* The Hong Kong University of Science and Technology
14:45-15:00	**Fabrication of Carbon Nanotube Field Emission Tip Array Based on Laser Processing and Research on the Characteristics of Field Emission Array (ASPEN2023P_007)** *Wei-Che Lin, Kao-Jen Lin and Hung-Yin Tsai,* National Tsing Hua University
15:00-15:15	**Laser-Assisted Nanoimprint on Glass Materials and Its Mechanism (ASPEN2023P_068)** *Takehiro Mitsuda, Keisuke Nagato and Masayuki Nakao,* The University of Tokyo
15:15-15:30	**Ultra-short Time Meniscus-confined Electrodeposition at Nanoscale (ASPEN2023P_166)** *Yutao Wang and Yuan-Liu Chen,* Zhejiang University

15:30-15:45	**Micro-transfer-printing of Au Thin-film with Atomic Diffusion Bonding: Effects of Air-exposure Time and Stamp Modulus (ASPEN2023P_028)** *Naoyuki Tomura, Weigang Kong, Tatsuki Sugihara, Takahiro Kono and Arata,* Tokyo Metropolitan University
15:45-16:00	**Effect of Crystal Orientation on Micro-cutting Mechanisms of FCC Crystal: Crystal Plasticity Finite Element Simulation (ASPEN2023P_125)** *Zhenting Zhang, Hao Wang, Wenhan Zeng, Jane Jiang,* National University of Singapore

Time	Metrology (V) (Room 2)
Session Chairs:	Chunjin Wang, The Hong Kong Polytechnic University
14:00-14:15	**XYθ Displacement Sensor by Four Encoders for Wide and Precise Measuring of Holonomic Robot (ASPEN2023P_122)** *Ohmi Fuchiwaki, Masato Shiota, Eiji Kusui, Yohei Tsukui, Chihiro Sekine, Ryosuke Kinoshita,* Yokohama National University
14:15-14:30	**A PSF-model-based CNN Approach to Enhancing Microscopic Image Resolution (ASPEN2023P_109)** *Yu-Ting Cheng, Wei-Yun Lee and Liang-Chia Chen,* National Taiwan University
14:30-14:45	**Film Thickness Measurement by Ultrasonic Atomic Force Microscope (ASPEN2023P_165)** *Mingyu Duan, Chengjian Wu and Yuan-Liu Chen,* Zhejiang University
14:45-15:00	**Investigation of Optimal Conditions in Cube Machining Test on Five-axis Machining Center (ASPEN2023P_031)** *Tomohiro Sawada, Sota Kawakami and Yukitoshi Ihara*,* Osaka Institute of Technology
15:00-15:20	**Digital Lensless Holographic Microscopy for Optical Metrology (Invited Talk) (Virtual)** *Liangcai Cao*, Tsinghua University
15:20-15:35	**Evaluation of Fine Feed Table Positioning for Non-contact Support Based on the Squeezed-air Effect (ASPEN2023P_034) (Virtual)** *Yuma Tamaru, Tomohiro Ushijima and Hiroki Shimizu,* Kyushu Institute of Technology

Time	Bio / Optical/ Medical Manufacturing and Applications (II) (Room 3)
Session Chairs:	James Kit Hon Tsoi, The University of Hong Kong Wai Sze Yip, The Hong Kong Polytechnic University
14:00-14:25	**Freeform Phase Plate in Filament-induced Fluorescence Spectroscopy (FIFS) System (Session Keynote) (Virtual)** *Xing Zhao*, Nankai University
14:25-14:45	**Surface Treatment Methods for Dental Zirconia (Invited Talk)** *James Kit Hon Tsoi*, The University of Hong Kong
14:45-15:00	**Development of a Novel Deformable X-Ray Mirror Based on a Single-crystal Piezoelectric Elements (ASPEN2023P_067)** *Junya Yoshimizu, Takato Inoue, Maaya Kano, Sota Nakabayashi, Yoshiki Kohmura, Makina Yabashi, Satoshi Matsuyama*, Nagoya University
15:00-15:15	**Separating Glass Sheets via Mechanically, Selectively Induced Median Cracks (ASPEN2023P_097)** *Sho Itoh, Souta Matsusaka, Hirofumi Hidai, Kumiko Murakami and Mitsuru Kitaichi,* Chiba University
15:15-15:30	**Si/SiC Ceramic Gradient Lattice Part Fabricated by Laser Powder Bed Fusion and Liquid Silicon Infiltration (ASPEN2023P_142)** *Ce Sun*, Wuhan University of Technology
15:30-15:45	**The Effect of Surface Roughness on the Sealing Performance of Mechanical Joints with Liquid Gaskets (ASPEN2023P_060)** *Akira Kakuta, Yuki Saikachi and Yuto Masujima, National Institute of Technology,* Tokyo College
15:45-16:00	**Optical Design and Analysis of Micro-grooves Machined by Ultra-precision Machining (ASPEN2023P_193)** Cheung Tong Cheng, Suet To*, *The Hong Kong Polytechnic University*

List of Posters Presentations

Poster Board	Abstract/Paper Number	Abstract/Paper Title and authors
Additive Manufacturing		
P-01	ASPEN2023P_037	**Surface Quality Control of Hole with Overhang Feature in Additive/Subtractive Hybrid Manufacturing** *Qian Bai, Wenmei Yang, Wenzhuo Zang, Yichen Tang,* Dalian University of Technology
P-02	ASPEN2023P_113	**Fabrication of Ti-6Al-4V Contouring Structure by M3DPen Process** *Insoo Jo, Seok Kim, Young Tae Cho,* Changwon University
P-03	ASPEN2023P_117	**A Study on Remanufacturing of Irregularly Damaged Part of The Old Planner Miller Using a DED Process** *Kwang-Kyu Lee, Dong-Gyu Ahn, Jeong-Won Lee,* Chosun University
P-04	ASPEN2023P_131	**Advancing Direct Writing of Elastomeric Fiber for Engineering Meso/Micro Devices** *Yu Liu, Wenzhen Yang, Erwei Shang, Zhenyu Wang, Xinghao Zhang, Jiawen Xu, Dongya Li,* Jiangnan University
P-05	ASPEN2023P_164	**Enhanced Mechanical Performance of Laser Additive Manufactured Tix-Alcocrfeni2.1 High Entropy Alloys** *Yixuan Sun, Chunjin Wang, Xingdong Dan, Chuanxi Ren, Xiaoliang Liang, Chi Fai Cheung, Zibin Chen,* The Hong Kong Polytechnic University
Atomic and Close-to-atomic Scale Manufacturing (ACSM)		
P-06	ASPEN2023P_121	**Atomic Scale Polishing of $LiNbO_3$ Crystal by a New Chemo-mechanical Slurry** *Pengfei Zhang, Zhe Yang, Xu Zhu, Jiang Guo, Zhen Tong, Lin Li,* Dalian University of Technology
P-07	ASPEN2023P_143	**Influence of Point Defects on Ultrashort Laser Pulse Interaction with Silicon: Enhancing the Atomic Layer Etching Process** *Peizhi Wang, Fengzhou Fang,* University College Dublin
Automation, Mechatronics, and Robotics		
P-08	ASPEN2023P_101	**Path Planning and Control of Industrial Robot Arm Using Depth Camera-based Hand Position Recognition** *Bum Jin Kim, Bo Wook Seo, Seok Kim, Young Tae Cho,* Changwon National University
P-09	ASPEN2023P_114	**Analysis of Estimable Link Parameter for Accuracy Improvement of 6-axis Serial Robot** *Seung-Han Yang, Heung-Ki Jeon, Eun-Young Ko, Sang-Ryong Lee, Young-Hun Jeong, Sung-Hwan Kweon and Kwang-Il Lee,* Kyungpook National University
P-10	ASPEN2023P_156	**Sigmoid-curve Interpolator of a 3-UPU Parallel Mechanism Considering Dynamic Models** *Chih-Wei Lee, Cheng-Kuo Sung and Yu-Jen Chiu,* Ming Chi University of Technology
P-11	ASPEN2023P_173	**Development of Machine Tending Process Reference Model for Automation in Machining Process** *Jin-Seok Kim, Ki Hyeong Song, Dong Yoon Lee,* Korea Institute of Industrial Technology
P-12	ASPEN2023P_175	**Connection and Integrated Operation of Heterogeneous Robots for Parts Machining Process Automation** *Ky-hyeong Song, Jin-seok Kim, Dong-Yoon Lee,* Korea Institute of Industrial Technology
P-13	ASPEN2023P_181	**Precision Laser Soldering System based on Collaborative Robotic Arm** *Jiacheng Liu, Lun Shi, Cong Zhang, Mingchao Li, Kuan Yan, Sikai Wang,* Wuhan Institute of Technology

Bio / Optical/ Medical Manufacturing and Applications		
P-14	ASPEN2023P_163	**Blood-repellent Structured Surfaces with Enhanced Hardness Fabricated by Nitrogen-assisted Femtosecond Laser Ablation** *Ziai Liu, Shiwei Wang, Wei Li,* Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences
P-15	ASPEN2023P_169	**Optical Properties of Glass with Trailing Indent Cracks During Chemical Etching** *Huapan Xiao, Chi Fai Cheung, Shenxin Yin and Chunjin Wang,* The Hong Kong Polytechnic University
Digital Manufacturing		
P-16	ASPEN2023P_123	**Unified CNC Interface Platform for Heterogenous CNC Systems** *Dong Yoon Lee, Eunseok Nam, Sung Ho Nam,* Korea Institute of Industrial Technology
P-17	ASPEN2023P_174	**A Study on the Current Characteristics of Spindle Motors in CNC Machining Centers during Processing** *Jaehyeok Kim,* Korea Institute of Industrial Technology
P-18	ASPEN2023P_177	**Cutting State Monitoring Using CNC Signals** *Young Hun Jeong, Dong Uk Kim, Gyubok Choi, Seung Hwan Lee, and Gyu Man Kim,* Kyungpook National University
High Speed and Precision Machining		
P-19	ASPEN2023P_003	**Investigation Of Ductile-brittle Transition Dynamic Behavior of Tungsten Carbide in Laser-assisted Diamond Machining Based on Discrete Wavelet Transform** *Jinyang Ke, Xiao Chen, Jianguo Zhang and Jianfeng Xu,* Huazhong University of Science and Technology
P-20	ASPEN2023P_016	**Ultra-precision Cutting Parameters Generation for Material Consistent Removal of Tungsten Alloy Complex Curved Surface Parts** *Feng-ze Qin, Hua-jun Cao, Jin Zhang, Jian-xiong Dong,* Chongqing University
P-21	ASPEN2023P_038	**Cutting Characteristics of Cold Worked Steel for High Tensile Strength Steel Forming Dies Tempered to 60HRC** *Yuya Kobaru, Rinta Fukuchi, Kenji Shimana, Shinichi Yoshimitsu,* National Institute of Technology, Kagoshima College
P-22	ASPEN2023P_047	**Numerical and Experimental Investigation on Spindle Axial Drift Considering Rotation Speed and Manufacturing Error in Ultra-precision Cutting Machining** *Wenyuan Wei, Qiang Gao, Lizi Qi, Jingfeng Xu, Liang Liu, Lihua Lu,* Harbin Institute of Technology
P-23	ASPEN2023P_146	**Influence of Negative Rake Angle For N-BK7 Glass of Laser-assisted Diamond Turning** *Yintian Xing, Suet To,* The Hong Kong Polytechnic University
P-24	ASPEN2023P_147	**Lubrication Mechanism and Machinability of Multi-dimensional Mixed Nano-lubricant in Ultra-precision Grinding of Binderless Tungsten Carbide (WC)** *Yanbin Zhang, Fan Zhang, Chi Fai Cheung, Chunjin Wang,* The Hong Kong Polytechnic University
P-25	ASPEN2023P_150	**The Application of Knowledge Management: Investigation of Main Themes and Recommendations for Prospective Ultra-precision Machining (UPM)** *Hengzhou Edward Yan, Feng Guo, Baolong Zhang, Wai Sze Yip, To Suet, Wanxin Li,* The Hong Kong Polytechnic University
P-26	ASPEN2023P_159	**Magnetic Field-assisted Chatter Suppression in Diamond Turning** *Denghui Li, Wai Sze Yip, Suet To,* The Hong Kong Polytechnic University
P-27	ASPEN2023P_162	**High-frequency Ultrasonic Vibration-assisted Diamond Turning of Micro-grooves on Tungsten** *Tengfei Yin, Suet To,* The Hong Kong Polytechnic University

P-28	ASPEN2023P_178	**Fast Fabrication of Si Microlenses Combined with Ultrasonic Elliptical Vibration Sculpturing and In-situ Laser Assisted Diamond Cutting** *Xinhuan Li, Haoqi Luo, Jiaxin Hao, Jianguo Zhang, Jianfeng Xu* Huozhong University of Science and Technology
P-29	ASPEN2023P_179	**Form Error Estimation in Milling Process using Monitoring Data** *Soohyun Nam, Jaehak Lee, Jun Kim, Jeongin Koo, Eunseok Nam,* Korea Institute of Industrial Technology
P-30	ASPEN2023P_180	**A Preliminary Study on Robotic Ultrasonic Cutting of CFRP Preforms for the RTM Process** *Tae Hwa Hong, Hyeong Gu Kim, Jungsoo Nam, Kyeongeun Song, Tae-Gon Kim, Seok-Woo Lee and Seong Hyeon Kim,* Korea Institute of Industrial Technology
P-31	ASPEN2023P_189	**Study on Orthogonal Cutting Force Model of Ceramic Matrix Composites** *Yan Bao, Hanbin Liu, Haonan Ma, Zhigang Dong, Renke Kang,* Dalian University of Technology
P-32	ASPEN2023P_190	**Effect of Wheel Path in Raster Grinding on Surface Accuracy of an Off-axis Parabolic Mirror** *Shang Gao, Xiaoguang Guo, Jianhe Li, Renke Kang,* Dalian University of Technology
IoT / AI / Big Data in Manufacturing		
P-34	ASPEN2023P_048	**Profile Prediction in Electrochemical Jet Machining by Machine Learning** *Yi Yuan, Yonghua Zhao,* Southern University of Science and Technology
Manufacturing Systems and Machine Tools		
P-35	ASPEN2023P_035	**Effect of Cutting Fluid on Surface Processing with Non-Rotational Cutting Tool using Damping Alloy** *Kenji Shimana, Shintaro Arikawa, Ryuichi Iwamoto, Yuta Kurigeno, Yuya Kobaru* National Institute of Technology, Kagoshima College
P-36	ASPEN2023P_075	**Temperature Dependence of Plasma Etching Properties of SiO_2 Using High-Pressure Plasma** *Takeuchi Daichi, Ryohei Asada, Daisetsu Toh, Jumpei Yamamda, Kazuto Yamauchi, Yasuhisa Sano,* Osaka University
P-37	ASPEN2023P_089	**Fabricating Hydrophobic Pillar Arrays on Brittle Materials Using Laser Structured Grinding Wheel and Integrated On-machine Surface Metrology System** *Zhongchao Geng, Chi Fai Cheung, Zhen Tong, Wenbin Zhong, Xiangqian Jiang,* University of Huddersfield
Metrology		
P-38	ASPEN2023P_009	**On The Spring Effect of Linear Ball Guides and Its Functions Towards an Ultra-precise Positioning** *Shigeru Futami,* THK Co. Ltd.
P-39	ASPEN2023P_072	**High-resolution Multiplexed Optical Spectrometer with Wide Spectral Range** *Jin Hee Cho, Ki-Nam Joo,* Chosun University
P-40	ASPEN2023P_073	**Optical Sectioning Structured Illumination Microscopy with Improved Lateral Resolution for Micro Pattern Measurement** *Jongkyu Park, Ki-Nam Joo,* Chosun University
P-41	ASPEN2023P_074	**Roughness Analysis Method of Polarization Lateral Shearing Interferometry** *Hyo Mi Park, Luke D. Mayer, Daewook Kim, Ki-Nam Joo,* Chosun University
P-42	ASPEN2023P_090	**Holographic Null Test for Corrective Machining of Monolithic Multiple Freeform Mirrors** *Shanyong Chen, Tao Lai, Chunyang Du, Cheng Huang, Xiaoqiang Peng* National University of Defense Technology
P-43	ASPEN2023P_118	**Development of Rotational Motion Fourier Transform Spectrometer through Design Optimization with 0.1 cm^{-1} Resolution** *Jungyoon Kim, Woojeong Lee, Joohyung Lee,* Seoul National University of Science and Technology

P-44	ASPEN2023P_134	**Development of a Novel on Machine Monitoring System in Ultra-precision Diamond Cutting** *Louis Luo Fan, Wai Sze Yip, Suet To,* The Hong Kong Polytechnic University
P-45	ASPEN2023P_183	**Target-recognition-assisted Smart 3D Measurement of Multi-layered Glass Based on Autostereoscopic Technologies** *Da Li, Chi Fai Cheung, Sanshan Gao, Jingfan Wang, Xing Zhao,* Nankai University
Micro/Nano Fabrication Processes		
P-46	ASPEN2023P_056	**Electrical Properties of Silver Nanowires Prepared by Nanoskiving Approach** *Zhuo Fang, Yongda Yan, Ji Ma, Yanquan Geng,* Harbin Institute of Technology
Molding and Forming Technology		
P-47	ASPEN2023P_053	**Fundamental Study on Influence of Ground Surface Characteristics on Mold Releasability in Compression Molding of Thermosetting Phenol Resin** *Qin Wang, Ryoji Kitada, Koki Yoshida, Akira Okada,* Sojo University
P-48	ASPEN2023P_133	**An Investigation of The Precision Hot Embossing Process for Micro-nano Structured Surfaces on Chalcogenide Glass** *Zhanchen Zhu, Tianfeng Zhou, Chi Fai Cheung, Chunjin Wang, Haihui Ruan, Xusheng Yang,* The Hong Kong Polytechnic University
Non-traditional Machining Processes		
P-49	ASPEN2023P_011	**A Study for Uniform Laser Hardening of Steel Parts with Convex and Concave Corners** *Keiji Ogawa, Hirotaka Tanabe, Masanori Fuwa, Heisaburo Nakagawa, Hirohito Tsukada, Yuki Goto,* Ryukoku University
P-50	ASPEN2023P_013	**Applications of Ultra-precision Mechanical Cleavage Technology on Semiconductor Lasers with Broad Area Mirror Facets** *Rui Gao, Chunjin Wang, Qingzheng Zhang, Chen Jiang, Chi Fai Cheung,* The Hong Kong Polytechnic University
P-51	ASPEN2023P_023	**Passivation and De-passivation in ECM: Fundamentals and Applications** *Bangyan Dong, Weidong Liu, Younghua Zhao,* Southern University of Science and Technology
P-52	ASPEN2023P_040	**Feasibility Study of Ultrasonic Vibration Assisted Grooving for Zirconia Ceramics** *Chen Deng, Te Zhao, Qiang Wang, Yuhan Chen, Xiaoliang Jin, Yongbo Wu,* University of British Columbia
P-53	ASPEN2023P_058	**Research on the Grindability Improvement of Titanium Alloy by Ultrasonic Assisted Plasma Oxidation** *Hanqiang Wu, Zhuo Chen, Ximing Ye, Shibo Zhang, Sisi Li, Jiang Zeng, Qiang Wang, Yongbo Wi,* Southern University of Science and Technology
P-54	ASPEN2023P_061	**Autonomous Generation Process of Nano- and Micro-textured Surfaces by Molecular Beam Epitaxy Using a Helicon Sputtering Molecular Beam Source** *Akira Kakuta, Yuma Takahashi, Ryota Tezuka,* National Institute of Technology, Tokyo College
P-55	ASPEN2023P_077	**A Study of Magnetic Field-assisted Batch Polishing on Structured Surfaces** *Yee Man Loh, Chi Fai Cheung, Chunjin Wang, Rui Gao,* The Hong Kong Polytechnic University
P-56	ASPEN2023P_135	**Experimental Study on 4H-Sic Magnetic Field-assisted Ultra-precision Grinding** *Te Zhao, Tengfei Yin, Suet To,* The Hong Kong Polytechnic University
P-57	ASPEN2023P_136	**Phenomenon and Mechanism of Shape Transition During the Ablation of WC Ceramic by Picosecond Laser** *Xiong Zhang, Chuncheng Zhai, Chunjin Wang, Chi Fai Cheung,* The Hong Kong Polytechnic University
P-58	ASPEN2023P_140	**The Laser Surface Treatment of Polycrystalline Diamond Wafers** *Lingda Xiong, Chunjin Wang and Chi Fai Cheung,* The Hong Kong Polytechnic University

P-59	ASPEN2023P_187	**Study on the Effect of Photoelectric Field on Photoelectrochemical Mechanical Polishing of GaN** *Yuewen Sun, Renke Kang, Yang Zhao, Zhigang Dong,* Dalian University of Technology
P-60	ASPEN2023P_191	**Study on Polishing Mechanism of Diamond Utilizing Reaxff Simulations** *Song Yuan, Chunjin Wang, Chi Fai Cheung,* The Hong Kong Polytechnic University
Precision Machine Design		
P-61	ASPEN2023P_051	**Influence of Fluid-Structure Interaction and Eccentricity on The Aerostatic Guideway's Lateral Stiffness** *Lizi Qi, Qiang Gao, Lihua Lu,* Harbin Institute of Technology
Surface Properties and Characterisation		
P-62	ASPEN2023P_027	**Diamond Growth Mechanism on Machined Stainless-steel Surface** *Ryoya Shiraishi, Hiromichi Toyota, Kyonosuke Harada, Takenobu Mizumura,* Yamaguchi University
P-63	ASPEN2023P_100	**Surface Structure Change According to Viscosity of UV Curable Resin Used for Nanowire Replication** *Myung Seo Kim, Seok Kim, Young Tae Cho,* Changwon national university

Abstracts for Oral Presentation

Abstracts for Oral Presentations

Day 2, 23rd Nov 2023 (Thursday)
Time: 8:30-10:30

Micro/Nano Fabrication Processes (I)
Venue: Room 1

ASPEN2023P_046
Tool-wear-free Electrochemical Discharge Machining via Electrolyte Jet
Yonghua Zhao* **and Jiajun Lu**
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Abstract
While the introduction of discharge into electrochemical machining allows for considerable improvement in the machining performance, tool wear becomes a non-negligible issue. This study introduces a new approach to realizing tool-wear-free electrochemical discharge machining via a free electrolyte jet, namely jet-electrochemical discharge machining (Jet-ECDM). The machining mechanism and key process parameters are clarified through experiments, and the versatility of this technique is demonstrated on both semiconductors and valves metals. More importantly, the finding shows that Jet-ECDM presents a superior solution to realize coating-microstructure integrated fabrication and anisotropic machining.

Keywords: Jet-electrochemical discharge machining, Tool wear, Plasma electrolysis, Plasma electrolytic oxidation, Mechanism and characteristics

ASPEN2023P_155
Polishing of Ti_6Al_4V Internal Structures Made by Laser-based Powder Bed Fusion
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Abstract
Polishing of internal structures prepared by laser-based powder bed fusion (L-PBF) is challenging considering the complexity of L-PBF surfaces and specific inner structures. In this study, flat top, face up, side and face down surfaces with various printing angles made by L-PBF Ti6Al4V are characterized first. Then, surface characteristics of L-PBF straight channel with an inner diameter of 2 mm and lattice structure with a unit cell side length of 2 mm are comprehensively analyzed. The relationship of L-PBF surfaces, inner structures and printing orientations is established. To improve surface quality of L-PBF Ti6Al4V inner structures, a self-developed polishing system that can perform electropolishing (EP) and abrasive fluid polishing (AFP) is applied to polish the lattice structure and the straight channel. For L-PBF inner structures, it is found that multiple polishing of EP and AFP with different sequences shows better polishing effects than single polishing. Overall, utilizing the developed polishing system to investigate polishing effects of L-PBF internal structures provides a theoretical basis for improving polishing efficiency and achieving flexible control of L-PBF inner surface finish.

Keywords: Laser-based powder bed fusion, Internal structures, Electropolishing, Abrasive fluid polishing

ASPEN2023P_083

A Novel Single-microparticle Total Analysis System Driven by Optical Tweezers

Ryohei Omine, Yushen Liu, Shuzo Masui, Shotaro Kadoya, Masaki Michihata and Satoru Takahashi*
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Abstract
Microparticles in the environment play key roles in transportation of chemically or biologically toxic substances because of their high adsorption ability and high mobility. For instance, microplastics (1-5000 μm plastic particles) can adsorb toxic chemicals such as persistent organic pollutants (POPs) and heavy metals and convey them to wild creatures. While methods to analyze surface chemicals of such microparticles are needed for detailed estimation of their risks, current known ones are very limited. In this research, we propose a novel system of analyzing individual microparticles with automatic active manipulation by optical tweezers. In this system, sample microparticles are adaptively manipulated by automated optical tweezers, then analyzed in detail by touching their multiple surface points sequentially to the objects called "analysis ports," which provide various functions such as Raman spectroscopy, fluorescence spectroscopy, and biosensing. The advantage of the proposed system is that it enables multiple chemical analyses of the bulk and the surface of individual particles. In this paper, we demonstrated the availability of the proposed system by realizing adaptive position and orientation control of non-spherical polystyrene microparticles (about 10-100 μm) and detection of fluorescent reagent attached to the surface of the particles using an analysis port of local fluorescence illumination.

Keywords: Microparticles, Optical tweezers, Pollutants, Analysis system

ASPEN2023P_065

A Study on Tool Influence Function and Polished Surface Characteristics of Belt Polishing Spinel ($MgAl_2O_4$)

Jianbo Zhao, Sheng Wang* and Qingliang Zhao
Center For Precision Engineering, School of Mechatronics Engineering, Harbin Institute of Technology
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Abstract
Polycrystalline aluminate magnesium spinel (PAMS) ceramic, as a polycrystalline ceramic material, plays an essential role in the family of transparent ceramics. Its excellent optical and mechanical performance offers potential applications in transparent armors, missile domes, and laser and IR windows. Belt polishing is a sub-aperture polishing technique with considerable advantages for polishing deep and thin optical components. In this paper, a belt polishing system was developed based on an ultra-precision machine tool. The influence function model was established for the belt polishing system based on Preston's law and modified for spinel based on the spot polishing experiments. The modified model has acceptable stability with a less than 2% deviation ratio. The surface defects of polished spinel were observed using white light interferometry and microscope imaging. The effect of polishing parameters during the belt polishing on spinel was discussed. Furthermore, the effect of grain sizes during the belt polishing for polycrystalline materials was investigated, and the results indicate that the primary defect of large grain spinel caused by polishing is grain spalling pits. The polishing experiments with different abrasive states show that the loose abrasive is less efficient yet obtains a polished surface with fewer surface defects.

Keywords: Belt polishing, Spinel, $MgAl_2O_4$, Pressure correction, Removal function, Surface defects.

ASPEN2023P_012

Generation of Silicon Nanoparticles by Line-focused Laser Irradiation on Waste Silicon Powders

Daiki Nakano and Jiwang Yan*
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*yan@mech.keio.ac.jp

Abstract
Recently, silicon nanoparticles are attracting attention as a material for improving the performances of lithium-ion batteries and solar cells. However, conventional methods for producing silicon nanoparticles are expensive and time-consuming. In this study, we proposed a silicon nanoparticle generation method by line-focused laser irradiation on waste silicon powder. Line-focused laser was realized by converting spot-beam laser through an optical system, which enabled scanning a wide area at once. By reusing waste silicon powder, an industrial waste from semiconductor manufacturing process, nanomaterials can be generated at low cost. The effect of laser fluence and the distance between the target and the collecting substrate on generation amount was investigated. By selecting the processing conditions appropriately, silicon nanoparticles were successfully deposited on the collecting substrate. SEM observation showed that the diameter of the nanoparticles ranged between 40 and 100 nm. Compared to the spot-focused laser irradiation in the same laser power, about 50 times amount of silicon nanoparticles were generated per unit time. These results show the possibility of mass production of silicon nanoparticles at a relatively low cost.

Keywords: Nanoparticle, Laser processing, Silicon waste

Atomic and Close-to-atomic Scale Manufacturing

Venue: Room 2

ASPEN2023P_145

Exploring Pulsed Laser Modification and Ablation at Close-to-atomic Scale

Haojie An, Jinshi Wang and Fengzhou Fang*
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Abstract
Semiconductor materials play an irreplaceable role in the development of the information technology revolution. The ultra-precision machining of these hard and brittle materials is likely to be achieved by pulsed laser technology rather than traditional machining methods. This paper presents the ablation and modification of GaAs at the close-to-atomic scale in air by pulsed laser. At near threshold energy, the surface modification was detected with a thickness of ~3.5 nm. At high fluences, ablation region was observed in the center. A three-dimensional two-temperature model-based molecular dynamics method was developed to study the laser-material interaction process. The ablation is attributed to the phase explosion mechanism caused by the fast laser energy deposition. In addition, surface modification at the atomic scale was explored by the simulations. This work provides guidance for precision processing of hard and brittle materials towards to atomic and close-to-atomic scale.

Keywords: ACSM, Molecular dynamics, Pulsed laser, Surface modification

ASPEN2023P_120

Atomic Observation of Structural Evolution of Turning Aluminum Surface during Ion Beam Bombardment

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Abstract

Revealing structural evolution of turning aluminum surface during ion beam bombardment will benefit the optical s urface quality modulation of aluminum, which is significant but challenging. In this paper, we present a molecular dynamics study on structural evolution and atom diffusion during ion beam bombardment. Metamorphic layer will generate during single point diamond turning causing massive sub-surface defects, which increases with the turnin g depth. During ion beam bombardment, the defects will perish with cascade collision. Thus, local stress will be r eleased. Atom diffusion will be blocked by subsurface defects, which will decrease the degree of cascade collision. The whole surface presents a more stable state, which will benefit the surface roughness control during ion beam bombardment, thereby inducing a better finishing surface quality. The work gives an atomic-level insight into the s tructural evolution of turning aluminum surface during ion beam bombardment. The results provide guidance for th e application of ion beam bombardment in the fabrication of high-surface quality of aluminum optics.

Keywords: Aluminum, Ion beam bombardment, Structural evolution, Molecular dynamic

ASPEN2023P_045

Large-area Fabrication of Micro-grooves on Ferrous Metals by Ultrasonic Vibration-assisted Turning with Laser-modified Cbn Tools

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Abstract

Demands of micro-structured surfaces, such as micro-grooves, are increasing for their unique characteristics on controllable wettability as well as better self-cleaning, which demonstrates remarkable benefits for ferrous metals to eliminate surface rusting and corrosion. In this manuscript, a novel micro-groove fabrication approach by ultrasonic vibration-assisted turning with laser-modified cBN edges is proposed. First, the cutting edges of the cBN tools are modified by femtosecond laser processing. Then, fundamental cutting experiments are conducted to verify the feasibility of this method. Furthermore, the cutting processes are deliberately interrupted to save the cutting points for chip formation observation. Compared with the conventional turning process, the morphologies of the chips at the cutting points indicate significant differences on material deformation mechanism with the introduction of ultrasonic vibration. In addition, the ultrasonic vibration-assisted process shows decreased cutting force, suppression tool wear and better machining accuracies. These results clearly illuminate the feasibility and clarify the cutting mechanisms of the proposed method, which could easily achieve high-efficiency and low-cost micro-groove patterns on ferrous metals.

Keywords: Laser-modified cBN tool, femtosecond laser processing, ultrasonic vibration-assisted turning, ferrous materials, hierarchical micro-grooves

ASPEN2023P_091

Microgrooving of PZT by Femtosecond Pulsed Laser Irradiation

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Abstract

Lead zirconate titanate (PZT) is a piezoelectric ceramic material widely used for sensors and actuator components in the industry. There is an increasing demand for fabricating high aspect ratio microgrooves in PZT. However, conventional grooving methods make it difficult to fabricate such grooves due to the formation of wall tapers, which leads to functional defects in piezoelectric devices. In this study, we proposed a method to fabricate high aspect ratio microgrooves without taper formation by femtosecond pulsed laser irradiation. The fundamental processing characteristics were investigated by changing laser scanning speed, laser fluence, and number of scans by using this laser, which has extremely low thermal effects and is expected to produce high-quality processing. It was found that the taper angle converges to a specific value by increasing number of scans. Based on this phenomenon, high aspect ratio grooves with a taper angle of 0.3° and 200 μm deep were successfully processed by irradiating at a specific inclined angle. The result of this study shows the potential of processing high-precision high aspect ratio slit shapes with perpendicular walls on PZT.

Keywords: Laser processing, PZT, Taper angle, Microgrooving

ASPEN2023P_084

A Microfluidic Step-emulsification Device with Nozzles Arrayed on a Slit

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Abstract
In conventional step-emulsification devices, accumulation and coalescence of droplets near the nozzles have been an issue. Here, we propose a new step-emulsification device capable of generating highly monodisperse droplets without their accumulation and coalescence. Our device consists of parallel channels where the dispersed and continuous phases flow towards each other and a vertical slit in the middle of the channels where the two phases meet to generate droplets by the step-emulsification regime. Using a device with 16 nozzles (nozzle end: 110 μm wide and 16 μm deep), we could generate monodisperse oil-in-water droplets with an average diameter of 62 μm and a coefficient-of-variation (CV) value of 2.5% with a maximum productivity of ~784 drops/s. Similarly, a device with 128 nozzles (nozzle end: 120 μm wide and 16 μm deep) could produce monodisperse droplets with a mean diameter of 67 μm and a CV of 2.6% at ~4096 drops/s.

Keywords: Step emulsification, Vertical slit, Droplet accumulation, Monodisperse

High Speed and Precision Machining (I)

Venue: Room 3

ASPEN2023P_014

Experimental Study of Electrochemical-assisted Drilling of Optical Glass

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Abstract
A novel method of electrochemical-assisted drilling is proposed in this paper to machine deep holes with a high aspect ratio in optical glass. In this method, the drilling tool is used as the cathode of the electrochemical-assisted process, and a large number of bubbles are generated on the surface of the tool electrode through electrochemical principles. The overflowing-bubbles carry the removed materials out of the machining area and refresh the coolant in the machining area. The temperature of the working area of the drilling tool is also reduced. The results show that the new method has significant effects in reducing tool wear and promoting drilling efficiency.

Keywords: ECM, drilling, optical glass, bubbles

ASPEN2023P_186

Electrochemical Mechanical Polishing of 4H-SiC by Polishing Pads with Through Holes

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Abstract

Single-crystal 4H-SiC is a typical third-generation semiconductor power-device material. However, in these power devices, the surface roughness and subsurface damage of the 4H-SiC substrate seriously affect their performance. Application of traditional chemical mechanical polishing (CMP) to 4H-SiC substrate can achieve an ultra-smooth surface and no subsurface damage. its extremely low material removal rate because 4H-SiC has extremely high mechanical strength and chemical stability. In this work, we report an efficient polishing method for 4H-SiC wafers that are electrochemically mechanically polished using polishing pads with through holes. The effect of 4H-SiC material removal uniformity in ECMP was investigated using the trajectory point density distribution, and the effect of through-hole arrangement and size variation on the trajectory point density distribution was simulated. The simulation and experimental results show that the use of polishing pads of a 10 mm through-hole structure can lead to a more uniform polishing effect on the whole 4H-SiC substrate surface. At 9 V anodic bias, the MRR can achieve 3.16μm/h, and the surface roughness can reach Ra 0.85 nm.

Keywords: 4H-SiC, Electrochemical mechanical polishing, Anodic oxidation, Material Removal Uniformity

ASPEN2023P_157

Machinability Improvement in Micro Milling AlN after Laser Chemical Milling

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Abstract

Processing microchannels inside AlN packaging can effectively solve the heat-dissipation problem of integrated chips. In this study, the machinability of AlN after laser chemical milling (LCM) is studied through the milling force, machined surface quality, surface defects, formation mechanism, and tool wear. This study establishes a milling force model that can predict the milling forces of AlN and analyses the reasons for the improvements in the milling force based on experimental data. The results from the model and experiments demonstrate that the milling force of the LCAMM decreased by 85–90% and 85–95%, respectively. Moreover, the machined surface quality improved by 65–76% after LCM , and the surface removal mode transforms from intergranular fracture to transgranular fracture. Therefore, milling after LCM can improve the machinability of AlN and providing a feasibility for the high-quality and efficient machining of microchannels.

Keywords: AlN, micro milling, machinability, milling force model, laser chemical milling

ASPEN2023P_167

The Direct Measurement of Cutting Temperature in Micro Zone Using a Boron-doped Diamond Tool

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Abstract

The thermal state of micro cutting zone in ultra-precision machining significantly affects the surface profile accuracy and tool wear intensity. The temperature of micro cutting zone near tool edge is difficult to directly measure due to the limitation of the low spatial resolution of the additional sensor. This paper presents a new cutting temperature measurement method, in which the cutting tool itself was as a function of temperature sensor for temperature measurement in the micro cutting zone. The self-sensing temperature of cutting tool was realized by the heat-sensitive characteristics as P-type semiconductor of diamond tool with boron doping. Equipped with the high-sensitivity signal acquisition and the high-spatial resolution function calibration method between resistivity and temperature, the cutting temperature self-sensing tool realized the online measurement of cutting temperature at tool edge in the single-point diamond turning processing of silicon.

Keywords: Cutting temperature measurement, Cutting temperature measurement, Boron doped d iamond tool, Single point diamond turning

ASPEN2023P_032

Fabrication of Functional Surface Using Water Jet Guided Laser Processing: Mechanism of Surface Structure Fabrication by Underwater Processing of the Workpiece

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Abstract
Surface functions, such as wettability, sliding characteristics, and optical properties can be provided by micro and sub-micro scale structures. In various processing methods, we focus on Water Jet Guided Laser (WJGL) processing owing to its advantages of low heat effects and the processed surface with random micro-uneven structures. WJGL processing is different from conventional laser processing in that it uses high-pressure water as a laser waveguide. The laser is coupled to the high-pressure water jet and propagates through it by total internal reflection. It is known that characteristic uneven microstructures are formed on the processed surface in response to complex processes such as the lateral intensity distribution in the water jet, the removal of molten materials, and the cooling of the heated area by the water jet. In this report, underwater processing of the workpiece is proposed as one of the methods to control the intensity distribution. Submerging the workpiece in water may make it possible to manipulate the processed area and the surface structure according to the depth of the water. The mechanism and the characteristics of underwater processing were discussed through the observation of the intensity distribution and the processed surface.

Keywords: Water Jet Guided Laser, Microstructure, Functional surface

Day 2, 23rd Nov 2023 (Thursday)
Time: 10:45-12:45

Micro/Nano Fabrication Processes (II)
Venue: Room 1

ASPEN2023P_085

High-speed Observation of Cathode Phenomena in Electrical Discharge Machining

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Abstract
In electrical discharge machining (EDM), the single pulse discharge craters generated on a cathodic workpiece normally shows irregular morphology which consists of many satellite craters around a main crater. The formation process of such morphology is not well understood yet. In this study, a high-speed observation setup was built to observe the cathode phenomena during a single pulse discharge in air. The results show that during the discharge, many visible bright spots would be generated within the cathodic arc root. Two types of spots were found on a cathodic steel workpiece: one is discrete spots with dim brightness and another one is concentrated spots with higher brightness. The two types of spots appeared intermittently during the whole discharge process. The synchronous discharge voltage recording shows that when the spots with higher brightness appeared, a high-frequency fluctuation formed in the voltage waveform. The observation and measurement results may provide important information for the understanding of the material removal and discharge crater formation process on the cathodic workpiece in EDM.

Keywords: EDM, High-speed observation, Single pulse discharge, Cathode spots

ASPEN2023P_141

Study on Cutting Surface Integrity of Recast Layer of Superalloy

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Abstract
The machining process results in microstructure alteration and forms a grain refinement layer beneath the machined surface, which influences fatigue performance, corrosion resistance, and wear behavior of the parts. In this study, turning experiments under various cutting parameters were conducted. The depth of the grain refinement layer beneath the machined surface was characterized by electron backscattered diffraction (EBSD) according to grain size. Additionally, microstructures of the grain refinement layer were examined through transmission electron microscopy (TEM), revealing an equiaxed crystal structure with a low dislocation density, which is a characteristic product of dynamic recrystallization. Furthermore, we calculated parameters such as shear strain, strain rate, temperature, and shear energy density during the cutting process. Results indicate that there is a linear relationship between the difference in shear energy density and the depth of the grain refinement layer. Based on these results, a prediction model for the depth of the grain refinement layer was proposed, which is rooted in dynamic recrystallization.

Keywords: Superalloy, recast layer, machined surface integrity, fatigue life

ASPEN2023P_069

Investigation of Plasma Gas for Modifying Gallium Nitride in Plasma-assisted Polishing

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Abstract
Gallium Nitride (GaN) emerges as a highly promising contender for next-generation power devices due to its band-gap and high breakdown electric field. However, the inherent properties of GaN, including its high hardness and chemical inertness, pose significant challenges for conventional polishing techniques, resulting in limited efficiency and increased cost. Herein, we demonstrate plasma-assisted polishing (PAP), which entails surface modification by plasma irradiation followed by the removal of the modified layer using soft abrasive. In this study, plasma irradiation experiments were conducted on GaN wafer using various process gases such as CF4, O2, and H2O. And the plasma modification rate was evaluated through X-ray photoelectron spectroscopy (XPS) measurements, respectively.

Keywords: Gallium Nitride, Plasma-assisted polishing, Plasma irradiation

ASPEN2023P_043

Experimental Study on the Effects of Vibration Behavior on Squd

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Abstract
Hole drilling technology is one of the most essential methods on the field of processing. In general, drilling is widely used to remove materials in terms of low cost and high accuracy. However, small diameter drilling or processing high aspect ratio holes cause reduction of tool life due to less supply efficiency of cutting fluid and worse quality due to low chip removal. In recent years, many researchers have studied ultrasonic vibration-assisted machining, which combines drilling and ultrasonic vibration. It has been reported that the cutting force is reduced, and chips are broken into smaller pieces, which

improve chip removal. Thus, in this study, we have experimentally investigated the effects of vibration behavior on SQUD (Squeeze Drilling technology) . To conduct experiments, we designed and made the device that can control longitudinal and tortional vibration individually using two vibration generators. The effects of rotation angle, longitudinal amplitude, feed speed and phase difference between tortional and longitudinal vibration were investigated on the processing performance.

Keywords: longitudinal-tortional vibration, vibration assisted drilling, Squeeze Drilling, low energy consumption

ASPEN2023P_062

Effect of Ultra-precision Grinding of Sapphire on Polishing Performance

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Abstract

Sapphire optics holds significant promise for several applications, while machining challenges associated with high hardness and brittleness have limited its widespread service. Introducing ultra-precision grinding instead of conventional grinding/lapping processes to improve efficiency and suppress damage is interesting to investigate. The damage evolution laws of the polishing process on the sapphire after ultra-precision grinding were investigated, the ion beam polishing was used to eliminate Bell layer and subsurface damage. The grinding strategy of rough grinding, semi-precision grinding, and ultra-precision grinding was used to acquire different degrees of grinding damage, the influence of different grinding damage on the roughness and surface morphology of the polished process was studied. The results indicated that the time required for polishing to remove ultra-precision grinding damage was only 1/3 of that required for rough grinding. The KOH etching was employed to characterize the subsurface damage of polyurethane polishing, the subsurface damage was predominantly intertwined scratches, and no scratches were observed after ion beam polishing. In addition, ion beam polishing will reduce the surface roughness variation induced by etching. The process route of ultra-precision grinding, polyurethane polishing, and ion beam polishing facilitates the efficient manufacture of damage-free sapphire optical components.

Keywords: Sapphire optics, Ultra-precision grinding, Polyurethane polishing, Ion beam polishing, Subsurface damage

Metrology (I) | IoT/AI/Big Data in Manufacturing

Venue: Room 2

ASPEN2023P_029

A Novel Single-microparticle Total Analysis System Driven by Optical Tweezers

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Abstract

Microparticles in the environment play key roles in transportation of chemically or biologically toxic substances because of their high adsorption ability and high mobility. For instance, microplastics (1-5000 μm plastic particles) can adsorb toxic chemicals such as persistent organic pollutants (POPs) and heavy metals and convey them to wild creatures. While methods to analyze surface chemicals of such microparticles are needed for detailed estimation of their risks, current known ones are very limited.

In this research, we propose a novel system of analyzing individual microparticles with automatic active manipulation by optical tweezers. In this system, sample microparticles are adaptively manipulated by automated optical tweezers, then analyzed in detail by touching their multiple surface points sequentially to the objects called "analysis ports," which provide various functions such as Raman spectroscopy, fluorescence spectroscopy, and biosensing. The advantage of the proposed system is that it enables multiple chemical analyses of the bulk and the surface of individual particles. In this paper, we demonstrated the availability of the proposed system by realizing adaptive position and orientation control of non-spherical polystyrene microparticles (about 10-100 μm) and detection of fluorescent reagent attached to the surface of the particles using an analysis port of local fluorescence illumination.

Keywords: Microparticles, Optical tweezers, Pollutants, Analysis system

ASPEN2023P_059

Image Treatment of Spatter Flight Phenomena for Porous Metallic Parts Using Powder Bed Fusion

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Abstract

The Powder Bed Fusion (PBF) 3D printing method introduces porosity into the final structure of the printed part. It is necessary to be able to predict the percentage porosity when different percentages may be acceptable or desired. To do this, an image treatment method using high-speed imaging was developed to obtain feature values as the part is constructed [1]. This method breaks down the image such that only the prominent features, mainly the spatter, are visible [2]. Noise is then removed from the image and the feature values are isolated and quantified; the resulting processed image is shown in Figure 1. The program can output a variety of feature values including, spatter and particle count shown in Figure 2, and ejection angle is shown in Figure 3. Some feature values are summed, such as the spatter and particle counts, and some are averaged such as the ejection angle. These feature values are then used to predict the porosity via a least absolute shrinkage and selection operator (LASSO) model. Image treatment of the highspeed video has proven successful and the noise is able to be managed such that a useful number of particles can be analyzed.

Keywords: Powder Bed Fusion, Porosity, Spatter, Particle, High-Speed Imaging, Image Treatment

ASPEN2023P_021

Reducing Battery Temperature and Short Circuit Risk with AI-optimized Nanofluids-mineral Oil Immersion Cooling

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Abstract

As the use of electric vehicles continues to grow, ensuring their safety and performance is becoming increasingly important. One of the most significant challenges is managing battery temperature, which can affect both efficiency and safety. In this study, we propose an AI-based approach for optimizing the parameters of mineral oil-based nanofluids for immersion cooling. By optimizing the nanofluid parameters, we can effectively reduce battery temperature and prevent short-circuiting. However, traditional methods for optimizing these parameters can be time-consuming and costly. Our approach utilizes machine learning algorithms to efficiently identify the optimal configuration, resulting in significant improvements in battery performance and safety. Our experimental results demonstrate the effectiveness of this approach and its potential for widespread application in the electric vehicle industry.

Keywords: Immersion cooling, Graphene, Global optimization, Regression, Thermal management

ASPEN2023P_102

Improvement of the Transient Levitation Response of a Magnetic Levitation System Using Hybrid Fuzzy and Artificial Neural Network Control

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Abstract
Magnetic Levitation system (MLS) has gained significant attention due to their potential for high-speed and efficient transportation. However, achieving precise and stable levitation control, especially during transient states, remains a critical challenge. This paper proposes a novel approach to enhance the transient levitation response of maglev systems using a combination of fuzzy and artificial neural network control. By leveraging the strengths of both methodologies, the proposed control system aims to improve the overall stability, robustness, and performance of maglev systems during transient operations. This research paper investigates the design methodology, and simulation results of the proposed control system, highlighting its potential for real-world implementation.

Keywords: Magnetic levitation, Transient levitation response, Fuzzy logic, Artificial Neural network

Manufacturing Systems and Machine Tools

Venue: Room 3

ASPEN2023P_098

Thermal Error Estimation of Machine Tools by Data-fit Models Based on Multi-point Temperature Sensor

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Abstract
Thermal errors are an essential research issue, accounting for 70% of machine tool errors. IIoT (Industrial Internet of Things) data collection and system construction have recently become mainstream in manufacturing. However, a practical thermal displacement compensation system that utilizes much sensor information on the manufacturing floor has yet to be established. We have achieved highly accurate thermal displacement estimation by measuring temperatures at many points on a machine tool. However, finite element analysis based on detailed CAD models is computationally expensive and unsuitable for systemization. In this study, we investigated data-fit models that extract features of a physical model by using multi-point temperature information as input and relative displacement of tool center point (TCP) as output. We conducted thermal displacement measurement experiments on a 3-axis horizontal machining center and obtained time series data sets for the multi-point temperature of the entire machine and TCP relative displacement. We constructed linear and LASSO regression models, trained on experimental data of 307 multi-point temperature data from six operating patterns. As a result, the importance of temperature features was calculated from the regression coefficients, and a relationship was found between the expressiveness of the model and the number of sensors required.

Keywords: Machine tools, thermal error, IIoT, multi-point temperature, data-fit model

ASPEN2023P_082

Visualization Experiment of Immersion Cooling for Battery Thermal Management System Using Mineral Oil and Aluminum Nitride Nanofluids

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Abstract
With the improvement of the performance of electric vehicles, the heat generation of the battery increases, and the battery thermal management system becomes very important. Immersion cooling has become an important thermal solution, exposing the battery directly to the liquid to improve heat dissipation efficiency. Adding nano-aluminum nitride to the fluid can increase the thermal conductivity of the fluid. In this study, the concentration of the aluminum nitride nanofluid in mineral oil ranged from 0 to 3.0 wt%. According to the numerical simulation analysis, when simulating 16 batteries charging and discharging at 1C and 2C, the battery temperature is displayed. In addition, the experimental state and test temperature data are captured by a visualization testing platform to study the feasibility of nano-aluminum nitride in immersion cooling.

Keywords: Immersion Cooling, Aluminum Nitride, Nanofluid, Battery Thermal Management System

ASPEN2023P_015

Effect of Surface Processing of Co-28Cr-6Mo Alloy on Wear Behaviour of Ultra-high Molecular Weight Polyethylene in Artificial Joint

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Abstract
It is well established in the literature that polyethylene wear debris are involved in loosening of joint prostheses. The influence of the surface profile of Co-28Cr-6Mo alloy on the wear behaviour of ultra-high molecular weight polyethylene was investigated using a pin-on-disc wear machine. The surface profile of Co-Cr-Mo alloy was processed by using a microslurry-jet, and had a waviness curve with convex and concave parts with a pitch of millimetres in size. However, the superficial surface was processed to be mirror-finished. The surface profile was designed to control not only the volume of wear of polyethylene but also the morphological features of the wear debris. The processed Co-Cr-Mo alloy surface reduced the number of polyethylene particles, and increased the equivalent circle diameter. A microchamber device capable of both quantitative and time-dependent assessments of inflammatory cytokine secretion from human monocyte-derived macrophage was developed and the polyethylene wear particles were administrated. It was elucidated that the polyethylene wear particles generated from the processed Co-Cr-Mo alloy disc reduced the production of inflammatory cytokine secretion.

Keywords: Surface texturing, Artificial joint, Tribology, Wear debris, Surface profile

ASPEN2023P_024

A New Geometric-error Synthesis Model Based on the Abbe Principle of a Three-axis Machine Tool

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Abstract
Based on the rigid body model and small angle assumption, the traditional geometric error model uses a homogeneous transfer matrix (HTM) to establish the volumetric error of a machine tool. Most of the geometric errors are position-dependent geometric errors (PDGEs), but the position variable x is not included in the volumetric error models of FXYZ typical three-axis machine tools. Generally, the geometric error model describes the volumetric error relationship between the grating reading point and the tool or probe center. Each geometric error will produce a corresponding volumetric error at the corresponding position, but the HTM ignores the influence mechanism of each geometric error on the volumetric error. In order to clearly express the influence mechanism and include more synthesis position variables, a geometric error model based on the Bryan principle was established. Twenty-one geometric errors for a three-axis measuring machine were identified with a laser interferometer, and the measurement results were simulated and compared with the actual measurement results using the proposed geometric error model. The comparison results showed the correctness and effectiveness of

the geometric errors of the Bryan and Abbe principle. The establishment process of the proposed error model was simple, which was helpful for understanding the influence mechanism of the angle error in order to understand the influence of the machine structure and assembly on the Abbe error and to guide the design of the high-precision machine tool and the geometric error compensation of the machine tool.

Keywords: Geometric error model, volumetric error, Bryan and Abbe principle, machine tool

ASPEN2023P_092

Temperature Dependency of Stiffness in Machine Tool Spindle Using Carbon Fiber Composite

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Abstract

A machine tool spindle with a hybrid structure of steel and carbon fiber composite was developed. Our previous study showed that the thermal deformation of the developed spindle in the axial direction was reduced by the hybrid structure. However, the radial thermal deformation should be larger than that of the conventional spindle using a steel structure. The temperature dependency of the spindle stiffness might be increased by the radial thermal deformation. It leads to the stiffness change during the machining process. In this study, the temperature dependency of the stiffness was investigated for the developed spindle with the hybrid structure. A non contact excitation device was used to measure the stiffness during the spindle rotation. The experimental result showed that the temperature dependency of the stiffness was not significant and less than that of the conventional spindle using the steel structure. The obtained results showed that the developed hybrid structure was effective to improve the thermal robustness of the machine tool spindle.

Keywords: Machine tool spindle, stiffness, temperature dependency, carbon fiber composite

Day 2, 23rd Nov 2023 (Thursday)
Time: 13:45-16:00

Micro/Nano Fabrication Processes (III)

Venue: Room 1

ASPEN2023P_026

Predicted of Grinding Forces in Ultrasonic Vibration Grinding of Fused Silica Glass Based on the Stochastic Distributed Abrasive Grits

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Abstract

Ultrasonic vibration grinding (UVG) has been recognized as an efficient machining method for hard and brittle materials. In this paper, a theoretical model was proposed for predicting grinding force in UVG of fused silica glass with consideration of the stochastic distributed abrasive grits. Since the protrusion height of diamond grits was closely related to the grinding force, the modelling of the wheel end-face morphologies was performed to obtain the protrusion height data of diamond grits. Based on indention theory combined with energy perspective, a material removal rate model was proposed for establishing the grinding force model. Experiments were conducted to verify the validity of the proposed model, and the mean error between predicted and experimental force is 4.87%. The proposed model could be used in selecting process parameters for realizing high efficiency and precision UVG machining of fused silica glass.

Keywords: Ultrasonic vibration grinding, Grinding force, Fused silica glass, Stochastic grits

ASPEN2023P_095

Simulation of Wire Electrode Temperature in Wire Electrical Discharge Machining Based on Temperature Measurement Results by Two-color Pyrometer with Optical Fiber

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Abstract
In electrical discharge machining, wire breakage causes a decrease in machining efficiency. It is assumed that the main cause of wire breakage is the decrease in tensile strength of the wire electrode due to the increase in wire electrode temperature. In this study, the average temperature of the wire electrode was experimentally measured using a two-color pyrometer with optical fiber. In addition, discharge locations were measured experimentally. Simulation of wire electrode temperature distribution was performed using the measured wire electrode temperatures and discharge locations.

Keywords: Wire electrical discharge machining (wire EDM), Wire temperature, Simulation, Two-color pyrometer with optical fiber

ASPEN2023P_033

Bottom Cutting High-speed Edm Using Thin Plate Electrode

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Abstract
Die-sinking EDM progresses by repeating single discharges. In the process, the machining speed is slow because all the removed parts are discharged for debris. Therefore, a scooping EDM method using a frame electrode has been proposed. However, it is applied only to zinc alloys because the frame electrode disappears due to electrode wear.

In this study, we propose bottom cutting EDM using a thin plate electrode that can theoretically ignore electrode wear. In order to bend the thin plate electrodes in the horizontal direction, highly rigid stainless and phosphor bronze were selected as the electrodes. However, it was judged difficult to use both electrode because of the large electrode wear or the unstable discharge state. Therefore, we devised a hybrid electrode in which a copper thin plate is attached to the tip of both thin plate electrodes. Using the hybrid electrode, the characteristics of horizontal cutting EDM were investigated.

Keywords: Electrical discharge machining, Thin plate electrode, Height speed machining, Bottom cutting machining

ASPEN2023P_151

Numerical Investigation on Ultrasonic Assisted Multi-grain Scratching of Silicon Carbide

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Abstract
Silicon carbide (SiC) is widely used in aerospace and other fields due to their unique physical and chemical properties. During the grinding process of SiC, there are problems such as low material

removal efficiency and diverse forms of processing damage. Ultrasonic assisted grinding can reduce grinding force and improve machining quality by introducing ultrasonic vibration. However, the parameter design and preparation of grinding wheels in ultrasonic assisted grinding process are crucial for machining quality. This paper focuses on the grain shape and grain distance in ultrasonic assisted scratching, and conducts single/double grains ultrasonic assisted scratching finite element simulations. Firstly, a finite element simulation model of single grain scratch SiC with different grain shapes was established, and the scratching force and surface morphology of conventional scratching and ultrasonic assisted scratching were compared. Secondly, the interaction between double grains at different grain distance during the scratching process was further explored. Furthermore, the stress distribution and machined surface morphology of SiC during the conventional and ultrasonic assisted scratching of multiple grains were analyzed. The results showed that the removal rate of conical shape grains was high, and the surface morphology was flat, but the edges chipping significantly. In addition, under the assistance of ultrasound, the instantaneous scratching force of grains is relatively large, resulting in a large amount of material removal. When the grain distance is small, the interaction between the abrasive particles is more obvious, the scratching force is smaller. The research conclusion of this article provides theoretical guidance for efficient and low damage machining of SiC.

Keywords: Silicon carbide, Ultrasound assisted scratching, Material removal mechanism, Grain shape, Grain distance

ASPEN2023P_148

An Approach Towards an Integrated Process Control for Vibropeening

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Abstract

Vibropeening, a surface conditioning technology, has been proven to enhance the fatigue life of complex components like blisk airfoils. However, the current research on Vibropeening is significantly constrained by time-consuming Almen peening used for process control, traditionally executed both before and after the Vibropeening process. This paper introduces a step change method integrating Almen peening directly into the Vibropeening of components, with the objective of improving efficiency. Through several experiments, a specialized fixture is designed and validated. The results suggest that this integrated process control method could potentially decrease process time. Further experiments using IN718 and Ti64 strips demonstrate the feasibility of employing actual component material strips for process control. This advancement paves way for a broader adoption of Vibropeening in the aerospace sector and underscores the necessity for further exploration in this area.

Keywords: Vibropeening, Almen strips, Process control

ASPEN2023P_050

New Insights into Stray Corrosion Suppression in Electrochemical Jet Machining

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Abstract

Secondary stray corrosion of the machined surface is a serious issue in the practice of electrochemical jet machining (EJM). The general approach to avoid stray corrosion includes using a bipolar technique or applying viscous organic solution like ethylene glycol (EG). This study demonstrates new considerations into these approaches to further optimize the process. On one hand, the bipolar pulse waveform design principle is clarified for the first time to deepen the understanding of the bipolar pulse technique. On the other hand, a new EJM approach of using ethylene glycol/water mixed solution is proposed and investigated. The mixed solution allows for maximizing the processing efficiency while protecting the machined surface from pitting. The efficiency in 75% EG/water mixed solution, reaching

1.6 μm/s is 1.8 times that in pure EG, while ensuring a surface roughness Ra=16 nm. Finally, fabrication of a pit-free groove structure without stray corrosion was demonstrated on stainless steel 304 and IN718.

Keywords: Electrochemical jet machining, Ethylene glycol, Mixed solution, Surface integrity

Bio/ Optical/ Medical Manufacturing and Applications (I)
Automation, Mechatronics, and Robotics
Venue: Room 2

ASPEN2023P_149

Characterization of Damage Properties of Ultra-precision Machined KDP Crystals Under Intense Laser Irradiation

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Abstract
As a typical transparent optics with wide-bandgap, potassium dihydrogen phosphate (KDP) crystals are prone to introducing a large number of surface structural defects after ultra-precision machining. Under the condition of high-power laser services, the existence of these defects would cause severe damage to crystal, greatly reducing the laser damage resistance and posing a serious threat to its subsequent service. Herein, the damage of KDP crystals with surface defects under the irradiation of 355nm nanosecond laser was investigated. Photoluminescence spectroscopy was employed to characterize the properties of damaged crystals. The results indicated that more radiation-induced defects associated with hydrogen and oxygen atoms were introduced in the crystals. Besides, a large number of oxygen atom-dominated particles were distributed on the damage crater. Based on the post-damage characterization results, it can be inferred that the existence of surface structural defects is one of the main causations for exacerbating laser damage to the surface of ultra-precision machined crystals. This work provides new insights into the mechanism of laser-induced damage of KDP crystals, which has theoretical guidance for the subsequent repair of damaged optics.

Keywords: KDP crystals, Damage characterization, Photoluminescence, Radiation-induced defects

ASPEN2023P_005

Bacteria-assisted Production System for Functional Nano- and Microstructures Made with Programmable Viruses

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Abstract
In biological systems, efficient assembly of nanoscale structures is realized thanks to biomolecules which specifically recognize and bind to certain target. In recent years, by mimicking those biological mechanisms in laboratory, some assembly techniques including DNA origami have been developed for systematic production of functional nano- and microstructures. Here we newly propose a bacteria-assisted production system using viruses as programmable and replicable components of nano- and microstructures. As viruses, we utilize M13 bacteriophages because their coat protein can be genetically programmed to display peptides which bind to specific target including both organic and inorganic particles or bulk materials. The production process consists of 2 stages: component manufacturing and assembly. In the component manufacturing, viruses are genetically edited to bind to selected target and replicated through infection to host bacteria, E. coli. In the assembly process, the virus is attached to its binding target, whose position is controlled by optical tweezers. The product of

our production system can have various materials and structures, and it is expected to have various application fields such as drug delivery. In this report, as a first step of the validation of assembly process, the experiment to attach a virus to optically trapped nanoparticle is demonstrated.

Keywords: Nanostructure, Virus, M13 bacteriophage, Bacteria, Escherichia coli, Production system

ASPEN2023P_004

Small Multi-legged Robots for Moving on Wall Surfaces and Its Evaluation System for Adsorption Mechanism with Negative Pressure

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Abstract
In recent years, there has been an increase in the inspection and repair of aging infrastructures. However, the inspection and repair are very costly and time-consuming. Also, a shortage of skilled engineers has been the problem. That's why increase demand for autonomous robots that can inspect and repair. In particular, the wall surface needs to be inspected in high and narrow places, and automatic inspections are required. In this study, we focus on a multi-legged robot that can traverse uneven terrain and adsorption mechanism with negative pressure. We will study the adsorption mechanism and walking method to create a small robot that can enter a narrow place.

We consider the walking method that doesn't be the high center of gravity of the robot and doesn't increase the necessary adsorption force during walking, for achieving the small wall-climbing multi-legged robot. We use the ROS to simulate the walking and measure the center of gravity shift. We also conducted experiments be able to predict the inner pressure of the adsorption mechanism at the design stage. Merge both results experiment to evaluate the motor's performance and simulation of the walking method, we will be downsizing the multi-legged robot.

Keywords: multi-legged robot, adsorption mechanism, negative pressure, simulation, walking method, ROS

ASPEN2023P_080

Pose Estimation of a Mobile Robot for Accurate Object Detection using Digital Twin and Bayesian Optimization

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Abstract
In this study, we suggest a novel method to find the optimal pose of a mobile robot for a highest detection confidence. Industry 4.0, mobile robots, and machine vision algorithms play an instrumental role. Especially in smart factories, where the layout changes to market demand, full task automation requires that robots be able to accurately perceive target objects in environments that are not predefined. Despite considerable advancements in perception systems, the pivotal aspect of optimizing the positioning of the vision system itself remains under-explored, often leading to limited accuracy and adaptability of vision systems. Addressing this, our study introduces a novel solution: a mobile robot equipped with an RGB-D camera and driven by the You Only Look Once-v5 object detection algorithm. This system leverages a Digital Twin-based simulation environment coupled with Bayesian Optimization for selection of optimal base position. The Digital Twin offers a high-fidelity replica of the manufacturing workspace, facilitating validation of potential base positions. Meanwhile, the Bayesian Optimization seeks the optimal base position that maximizes object detection performance. Our approach enables the mobile robot to quickly find the optimal base position for accurate perception of target objects and dynamically adjust it in response to changing workspace conditions. This study promises the improvement of performance in existing vision systems by optimizing the base position of the mobile robot.

Keywords: Digital Twin, Bayesian Optimization, Mobile robot, Base position,, Object detection

ASPEN2023P_094
A Piezoelectric Stick-slip Manipulator for a Holonomic Precision Mobile Robot
Ryosuke Kinoshita, Eiji Kusui, Hazumu Kusama, Yohei Tsukui, Rintaro Minegishi, Yuna Sugiyama, Yuta Sunohara, Chihiro Sekine and Ohmi Fuchiwaki*
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Abstract
In recent years, compact electronic devices have been developed remarkably, and electronic chip parts inside them have become more compact, high-performance. Thus, precision technologies of handling micro-objects have become more important.

However, current precision positioning devices are too large in weight and size relative to the target object. To solve these problems, we are developing a piezoelectric XYθ precision mobile robot that is compact, lightweight, and can be operated in narrow spaces. even where conventional devices cannot be attached.

In this study, we developed a piezoelectric stick-slip manipulator for attaching the robot. It with the weight of 55.3 g, width of 62 mm and height of 48 mm has two degrees of freedom and consists of a Z-axis stage and tweezers mechanism. Firstly, we designed and evaluated an actuator using the piezoelectric stick-slip phenomenon. Then, by combining this actuator and a linear slider, we constructed a linear motion mechanism. The maximum force generated by the mechanism is more than 800mN and maximum speed reached 5 mm/s. Additionally, it able to move less than 1μm in precise mode.

Finally, we demonstrated pick-and-place, and stack manipulation with the manipulator mounted on the robot evaluating feasibility as multi-purpose operations.

Keywords: Piezoelectric actuator, Stick-slip actuator, Mobile robot, Walking robot

ASPEN2023P_129
Lightweight Design Methods for Water Strider Micro- robot Using Artificial Intelligence
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Abstract
The existing water strider micro robot design faces precision control challenges due to its propulsion method, which relies on surface tension. This restricts the robot's weight and precludes the use of an ample number of motors and actuators. Therefore, in this study, a circular design is adopted to minimize the weight of the robot and a single vibration motor is used for control, which can be controlled by utilizing the co-evolution frequency. By adjusting the length of the support legs, we can govern the robot's movement, allowing it to move straight and turn at varying vibration frequencies. High-speed camera imaging of the robot at each frequency helped us identify characteristics of the support legs and water surface, facilitating the determination of optimal vibration frequencies for straight motion and turns. Deep learning applied to the experimental data has revealed the correlation between the microrobot's movement direction and the motor's vibration frequency, enabling precise control of a water strider microrobot.

Keywords: Water strider micro robot, Lightweight design, Image analysis, Water surface image, Deep learning

Additive Manufacturing (I)
Venue: Room 3

ASPEN2023P_036

Feature Value Detection From High-speed Observation of Spatter for Prediction of Porosity in Metals Formed Using Powder Bed Fusion

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Abstract
Porous metallic materials are widely used in industrial applications such as light-weight parts or heat exchangers. To improve the performance of porous materials, it is useful to control the porosity and pore size as the range of design parameters beco mes wider. Although powder bed fusion (PBF) is a promising technique realizing the control of porosity and pore size, it requires a great d eal of time and effort to search for parameters to obtain the desired properties because the process parameter space is huge. Simultaneousl y, it is also difficult to develop through simulations based on thermofluidic dynamics because the phenomena at the laser spot are very complex.

In this study, we applied Bayesian optimization to explore the process parameters for porous materials. Bayesian optimization is a techni que optimizing the objective function with a small number of trials of process parameters [1]. However, it requires a certain time to obtain the porosity and pore size as objective functions by fabricating bulk samples and observing the cross sections. Therefore, we propose and develop a method to use intermediate features that can predict the final mechanical properties to reduce the cycle time of trial as shown in Figure 1.

Figure 2 shows the results of spatter number obtained by high-speed camera observation [2] and capillary efficiency determi ned by prototyping bulk samples as functions of laser power and scan speed. If the relationship between the two contours is w ell agreed, then the intermediate feature value will lead to an increase in the speed of parameter exploration.

[1] K. Nagai et al., Sci Rep.12:1615,2022 [2] K. Nagato et al., Mater. Des.227:111696,2023.

Keywords: powder bed fusion, porous, spatter, high-speedobservation

ASPEN2023P_096

Evaluating Particle Separation in a 3D-printed Deterministic Lateral Displacement Device

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Abstract
Fabrication of microfluidic devices by 3D printing instead of conventional photolithographic steps has several advantages, such as a large printing area, low cost, rapid operation, and fabrication capability. Previously, we reported a 3D-printed microfluidic deterministic lateral displacement (DLD) device for sorting droplets by their size through an array of square micro-posts. However, the actual critical diameter Dc of this DLD device, a cut-off value for separation, remained unclear. Here, we propose a new droplet-based method for evaluating a Dc of a DLD array using 3D-printed de vices. First, we prepared a cross-shaped microfluidic droplet generator (MFDG, 140 mm wide and 140 mm height) and DLD devices by a stereolithography 3D printer. Then, to determine the Dc of the DLD array, we connected the MF DG and DLD devices serially through a tube. The average droplet size decreased from 190 to 121 μm when the flow rate of the continuous phase increased from 4 to 15 mL/h These droplets were introduced into the DLD devices, where their trajectories were evaluated to obtain an empirical equation relating the actual Dc and geometrical parameters of the DLD array.

Keywords: microfluidics, 3D printing, deterministic lateral displacement, particle separation, droplet generation

ASPEN2023P_078

Effect of Laser Conditions on Surface Morphology After Powder Bed Fusion

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Abstract

In the process of additive manufacturing, the effect of laser melting on the surface of the workpiece is very important to its final shape. The laser forms a bumpy surface after it has finished passing over each powder layer [1]. Figure 1 shows the powder bed fusion process, the uneven surface of each layer will have a knock-on effect on the subsequent powder layers, and the physical characteristics of the final product will be affected by the aggregate of each of these ablations. Therefore, the laser parameters in the laser scanning process are of great significance, and it takes a lot of time to find the best results from the large volume of data. In this work, the velocity of the molten pool and the surface deformation is simulated by finite element analysis so that the most suitable laser conditions can be found to achieve the optimal melting effect. Figure 2 shows that the velocity of the molten pool surface and the surface roughness tends to decrease with increasing laser scanning speed, and when the laser power is too high, the velocity of the molten pool surface increases, which might cause sputtering of the molten metal as the laser irradiates it

Keywords: Selective laser melting, Molten pool, Numerical simulation, Multi-objective optimization

ASPEN2023P_110

Design of Chamber for Selective Laser Melting Based on Inert-gas Flow Simulation

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Abstract

Selective laser melting (SLM) is one of the additive manufacturing (AM) processes that can produces complex-shaped metal parts. By melting and solidifying the evenly spread metal powder with laser beam irradiation, the target shape is obtained by layer by layer. Although SLM is capable of high-precision processing, it is still challenging to remove spatter and fume that are generated from the melt pool and degrade the quality of deposition. The spatter and fume are generally removed by an inert-gas flow above the powder bed. In this study, fluid dynamics analysis is performed on inert-gas flow in SLM, and the purpose is to obtain high velocity and uniform flow over a large area by improving the design of the chamber. In the simulation, as the gas flow rate increased, the maximum flow velocity increased, but the velocity deviation became noticeable. The sufficiently large chamber and the gas inlet wider than the powder bed provided uniform flow over a larger area above the powder bed. It was confirmed that the detailed shape of the gas outlet has a large influence on the flow-velocity distribution.

Keywords: Additive manufacturing, Selective laser melting, Gas flow simulation, Computational fluid dynamics, Spatter

ASPEN2023P_049

Elucidation of Spatter Formation Mechanism with High-speed Observation of Melt Pool in Metal Powder Bed Fusion

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Abstract

Metal additive manufacturing is a process in which a laser beam is irradiated onto a layer of metal powder, causing the irradiated area to melt and solidify, this is then repeated in layers. However, this method has a problem in that spatter generated during laser irradiation reduces the strength[1] and surface quality of the fabricated object[2]. Since the detailed mechanism of spatter generation[3] has not yet been clarified, understanding this issue will be effective in realizing high-quality products in metal 3D printers. In this study, we constructed the experimental system shown in Figure 1(a) using a pulsed laser, a processing laser, and a high-speed camera, observed the melt pool in-situ during laser irradiation, and used image analysis to quantitatively examine the mechanism of spatter generation. As a result of the experiment, as shown in Figure 1(b), spatter due to recoil pressure scattered from the front region of the melt pool at about 12 m/s could be observed at 1,000,000 fps. By using image analysis on the obtained images, the velocities of the plume and sputter could be visualized. The close proximity of these speeds suggests that the sputter is driven by the plume.

Keywords: Metal additive manufacturing, Spatter, Laser, Image analysis, High-speed observation

ASPEN2023P_139

Ambient Vibration Conductance of FDM-printed PLA Components

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Abstract
Fused deposition modelling(FDM) fabricated components are used in many engineering applications. Recent mechanical characterization studies focus mainly on their static load-bearing capabilities. In this study, we subject FDM-printed polylactic acid(PLA) samples to ambient vibration-like conditions and measure their structural responses with high-sensitivity accelerometers. The samples had their printing layer height and infill percentage varied to see if there were any differences in their structural responses to such vibrational loading. Investigations have preliminarily concluded that the PLA samples tend to produce amplified dynamic responses in x,y and z directions. However, 2 samples with a 20% infill percentage produced damped responses when subjected to transverse vibration loading. This crucial finding hints that bulk-printed FDM components may have variations in their dynamic performances. From this study's insights, practitioners can have a clearer understanding of how FDM-printed PLA components may affect dynamic precision before integrating them into engineering applications.

Keywords: Additive manufacturing, structure dynamics, vibrations, precision engineering

ASPEN2023P_153

Analysis of the Relationship Between Process Parameters and Hardness for the Finishing Process by Wire Arc Additive Manufacturing Combined with the Fsb Tool of Austenitic Stainless Steel 316L

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Abstract
This research aims to investigate the optimum parameter on microhardness in the simultaneous processing system that combines the accumulation by wire arc additive manufacturing (WAAM) using wire material SUS 316L austenitic stainless steel and the finishing process by a milling machine using friction stir burnishing (FSB) tool. In our former studies, it was clear that the FSB process affects the molten metal begins to solidify after deposition at a depth of 0.7 mm from the top of the layer. In this combined FSB process, a mechanism by which microhardness of the melted material changes may be related to following three factors. Firstly, distance from torch to the FSB tool that cooling rate was determined by the balance between the cooling behavior via heat transfer from contact between the molten metal and the FSB tool. Secondly, cutting speed generated pressure on the weld deposition during solidification contact with the FSB tool may be influenced by suppressing the dendrite's growth,

the microhardness anticipates improvement. Thirdly, milling machine feed speed brought a change in the size and shape of the weld and the various zones that compose them. We used a design of the experiment technique (Taguchi orthogonal matrix) consisting of these parameters. And each parameter has three levels to investigate the optimum parameter of microhardness. After that the microhardness properties were compared to the specimen with simultaneous and without simultaneous processing. In addition, the simultaneous processing improved surface adaptation, and simplification of the finishing process is expected.

Keywords: Wire and arc additive manufacturing, Directed energy deposition, Friction stir burnishing, Taguchi, Microhardness

Day 2, 23rd Nov 2023 (Thursday)
Time: 16:15-18:15

Micro/Nano Fabrication Processes (IV)
Venue: Room 1

ASPEN2023P_086

Femtosecond Laser Direct Writing Based Laser-iInduced Graphene (LIG) Formation on Woods for Smart Home Realization

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Abstract
Wood is a widely used and environmentally friendly material known for its attractive qualities. However, its application is often limited by its non-conductive nature. In recent years, there has been growing interest in exploring ways to enhance the conductivity of wood, particularly in light of the increasing focus on carbon neutrality and environmental protection. This research addresses the challenge of wood's limited conductivity by investigating the use of Laser-Induced Graphene (LIG) electrodes. Previous research has demonstrated that LIG electrodes can be created by directly irradiating wood with a laser, leading to the carbonization and graphitization of the material. However, the combustibility of wood necessitates additional treatment or the use of a vacuum environment to prevent unwanted thermal ablation. This research explores the application of femtosecond (fs) laser direct writing technology to overcome the limitations associated with the formation of high-quality LIG electrodes on wooden materials. By utilizing fs laser direct writing technology, it becomes possible to suppress thermal ablation without requiring additional treatments, allowing for the formation of high-quality LIG electrodes in an atmospheric environment. The research methodology involves optimizing and analyzing the LIG electrodes through various characterization techniques such as sheet resistance measurement, XPS, XRD, SEM, TGA, and Raman spectroscopy. The electrodes are then applied to green electronics, specifically carbon electrode-based heaters, temperature sensors, touch sensors, and electrodes. Performance tests are conducted to evaluate the applicability of these LIG electrodes in wooden buildings and wood furniture. Through this research, we aim to explore the potential of fs laser direct writing technology in creating high-quality LIG electrodes on wooden materials. The findings of this study contribute to the broader understanding of wood-based conductive materials and their practical applications in green electronics.

Keywords: Green electronics, Laser-Induced Graphene, Femtosecond laser, Laser Direct Writing

ASPEN2023P_130

High-precision Acoustic Cell Sorting in BioMEMS

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Abstract
Biological cells in human bodies, as the fundamental unit of life, are heterogeneous in nature. It is essential to identify and sort specific cell populations from highly heterogeneous biological samples for a variety of applications in biology, diagnostics, and medicine. As acoustic waves can easily propagate through solids and fluids, acoustic technique readily enables non-contact cell manipulation in relatively long operating distances. It has been found that acoustic technique has no or minor negative impact on the viability and functionality of biological cells, which is a significant advantage compared to existing cell sorting technologies. Herein we will present high-precision single cell sorting in bioMEMS using highly focused surface acoustic waves (SAW). I will discuss a unique design of a focused interdigital transducer (FIDT) structure, which is able to generate a highly localized SAW field on the order of 25 μm wide that is comparable to individual biological cells. We have further integrated single cell analysis (i.e., single cell fluorescence detection and single cell biophysical phenotyping) with the acoustic cell manipulation to implement detection activated single-cell sorting. This new type of acoustic manipulation platform has enabled high-precision and on-demand single cell sorting in diverse biomedical applications.

Keywords: Acoustofluidics, Microfluidics, Single-cell analysis, Single-cell sorting, Precise cell manipulation

ASPEN2023P_115

Multiphysics Simulation of Micro Electrochemical Machining Including Circuit Analysis of Pulse Power Supply

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Abstract
In ultra-short pulse electrochemical machining, it is known that applying a voltage with a short pulse duration improves the machining accuracy. This is because the short pulse duration prevents the formation of an electric double layer at the wide inter-electrode gap distance. On the other hand, the inductance in the circuit wiring of pulse power supply affects the machining current. Therefore, in this study, workpiece geometry was simulated using a coupled analysis of the electric field between the electrodes considering the electric double layer and the circuit equations involving the inductance of the pulse power supply circuit. The simulation results showed that the machining depth became smaller when inductance was larger. This is because the inductance makes it more difficult for current to flow and thus prevents the formation of the electric double layer.

Keywords: Electrochemical machining,, Multiphysics simulation, Pulse power supply, Inductance

ASPEN2023P_008

Development of Deep Etching Method by Atmospheric Pressure Plasma Jet

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Abstract
Micromachining technology is important because it is a fundamental technology in the fabrication of microelectromechanical systems (MEMS). Semiconductor processes are used for fabrication, and problems remain in prototyping such as high production costs and long production periods. Therefore,

the development of a maskless, low-cost fabrication method is expected. In recent years, micromachining using an atmospheric pressure plasma jet (APPJ) has attracted attention. APPJs can be localized using a nozzle for maskless processing. The etching shape is restricted by the isotropic etching characteristics of APPJs, and the aspect ratio is about 1. When fabricating trenches used in MEMS and microchannels, it is required to increase the aspect of the structure. In this study, we developed a deep etching method that can fabricate structures with an aspect ratio exceeding 1 using an atmospheric pressure plasma jet. We have proposed a vertical deep etching method that repeats the positioning and irradiation of the APPJ. The nanopipette with an aperture diameter of 10 μm was used as the nozzle and a probe for positioning using a share force detection. The deep hole with a depth of 465 μm and an aspect ratio of 3.2 was successfully fabricated using the proposed method.

Keywords: Micromachining, Atmospheric pressure plasma

ASPEN2023P_158

Research on Surface Integrity Evolution of Short Arc Assisted Milling of Superalloys

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Abstract
Short arc milling technology is commonly used in the processing of nickel-based superalloys due to its advantages of low machining stress, cost-effectiveness, and high efficiency. However, the understanding of the evolution of surface integrity in short arc-assisted precision milling is still limited. This study aims to address this issue by analyzing the microstructure characteristics of the recast layer using scanning electron microscopy (SEM), energy dispersive spectrometry (EDS), and other detection methods. Additionally, the influence of precision milling process parameters on surface integrity and the differences in milling surface caused by the presence of the recast layer are investigated through orthogonal milling experiments. The surface strengthening mechanism of short arc-assisted precision milling is also elucidated. The findings reveal that the superalloy crystal undergoes destruction and recombination at high temperatures, resulting in the formation of a recast layer. This recast layer leads to a 34% reduction in hardness and an increase in brittleness. Furthermore, the surface roughness of short arc-assisted milling is found to be larger (Ra=0.76 μm) compared to other milling techniques, and the surface hardening rate is higher (47.8%). Dislocation strengthening is identified as the main factor contributing to surface hardening, and a microhardness change prediction model is developed accordingly.

Keywords: Short arc, Recast layer, Surface integrity, Microhardness, Surface strengthening

Metrology (II)

Venue: Room 2

ASPEN2023P_066

Development of X-Ray Fourier Ptychography Using a Mirror-based Achromatic X-Ray Microscope

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Abstract
X-ray microscopy enables unique observations by taking advantages of the short wavelength and high transmittance of X- rays. Furthermore, achromatic and highly efficient observations can be expected by using total-reflection mirrors. However, there are still challenges in improving spatial resolution. First, spatial resolution beyond the diffraction limit, which depends on the numerical aperture of the objective, cannot be achieved. Second, residual shape errors on mirrors that occur during fabrication process are

inevitable, resulting in optical aberrations and degradation of the spatial resolution. To solve these problems, we applied Fourier ptychography (FP) to X-ray microscopy. FP is a technique that improves spatial resolution by applying a special phase retrieval algorithm to multiple images acquired by scanning the illumination angle.

We report recent achievements of the X-ray FP using a home-built achromatic X-ray microscope equipped with total- reflection mirrors. Images of a test chart were successfully reconstructed and high spatial resolution (23nm) that exceeds the diffraction limit (42nm) of the used objective was achieved.

Keywords: X-ray microscopy, X-ray mirror, advanced Kirkpatrick-Baez mirror, Fourier ptychography

ASPEN2023P_079

Gas-cell Locked Frequency Sweeping Interferometry Achieving High-speed Absolute Displacement Measurement

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Abstract

This study introduces a novel gas-cell locked frequency sweeping interferometric (FSI) method for improved precision in absolute distance measurements. Traditional FSI approaches, due to inherent limitations, are ill-suited for dynamic measurements. Our solution combines a tunable laser, hydrogen cyanide gas cell, and an advanced algorithm. The laser enhances scanning range, while the gas cell locks its range, promoting stability and reliability. The algorithm enables sub-micrometer measurements within a 300 mm range. We tested the system using a precise wafer carrier positioning apparatus. The method delivered superior performance in both static and dynamic settings, even at speeds of 300 mm/s. Our innovative approach enhances measurement precision and dynamic capabilities, benefiting industries and science.

Keywords: Absolute displacement measurement, Frequency sweeping interferometry (FSI), HCN gas cell, Gas-cell locked interferometry

ASPEN2023P_076

Robust Surface Imaging Method Based on Quantum Single Pixel Imaging

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Abstract

Surface characterization is a fundamental aspect of scientific and technological fields. In recent years, quantum single pixel imaging has garnered significant attention, particularly Quantum Ghost Imaging (QGI). However, this approach has been shown to be susceptible to external perturbations, limiting its surface characterization capabilities. To address this issue, this research publication proposes an expansion of the classical QGI design. The proposed approach utilizes the spatial correlation of the imaging particles and includes a calibration experiment to calculate the Joint Probability Distribution of the optical setup. This enables more precise signal filtering, which effectively suppresses shot noise and noise due to parasite light. The results are compared to direct imaging and regular Ghost Imaging, and the findings clearly indicate that the novel approach is significantly less sensitive to noise, producing clearer images even in challenging conditions. The key advantages of this design include the ability to perform surface measurements at low light levels and with a high robustness to noise. This research presents a novel approach that enhances the robustness and quality of quantum imaging for surface analysis. The results have paved the way for advanced surface characterization techniques that leverage quantum imaging principles, providing valuable insights into surface properties.

Keywords: Quantum Ghost Imaging, Single Pixel Imaging, Low Noise Imaging, Simulation

ASPEN2023P_138

Design of Gaze Estimation Model Based on Multiple Feature Fusion

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Abstract
Gaze estimation is a fundamental task in many applications of cognitive sciences, human–computer interaction, and robotics. In this study, a multiple-feature fusion method based on the gaze conduction mechanism is proposed to improve the performance of the gaze estimation model. Accurate pupil localization is a crucial requirement in gaze estimation. A novel multi-directional pixel array computation method is proposed, which utilizes the gray-scale features of eye morphology to calculate pupil localization intelligently. Then, a feature element matrix is established that includes the original images, region images, pupil coordinates, and head pose vectors. According to the gaze conduction mechanism and the feature element matrix, gaze estimation models with different input modes and network structures are designed, and model training and test experiments are carried out on a large-scale dataset. Experimental results show that optimizing the feature combination and fine-tuning the computational architecture can improve the performance of the gaze estimation model, which would enable the reduction of the model by incorporating the critical features and thus improve the performance and accessibility of the method. The average error is 1.63 cm on the GazeCapture dataset, which achieves comparable accuracy with state-of-the-art methods.

Keywords: Gaze estimation, Artificial intelligence, Human computer interaction, Metrology

ASPEN2023P_132

Automated Detection of Mediterranean Snail in Australia Agricultural Fields Using Machine Vision

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Abstract
Introduced Mediterranean snails have become significant challenges in pest control for Australia. These snails not only pose a threat to crops but also contaminate harvested grain because they remain at the top of crop plants at the time of harvesting. Consequently, crop damage, harvest delays, and grain value downgrades at delivery, are the major concerns for growers in affected areas. Detection snails in agricultural fields is of upmost importance for effective snail management. An automated detection system is expected to reduce the cost and complexity associated with this task. Furthermore, with a view to achieve good detection results and make this system more affordable for growers, the authors proposed a low-cost multi-spectrum camera detector embedded with machine learning. As snails, plants, and the environment in general respond to light differently when appeared in images at different wavelength, this paper aims to evaluate the detection efficacies using different wavelength ranges under natural light conditions. Through assessing the performance across various wavelength ranges, the optimal wavelength range and/or the combination of wavelengths for the development of a tailored multi-spectrum camera can be determined. The outcomes of this study contribute to the development of an affordable and efficient camera solution for snail detection.

Keywords: Multispectral, Snail detection, Machine learning, Smart agriculture, Pest control

ASPEN2023P_099

Heating Process Effects Before Hot Water Treatment in Injection Molding Direct Joining

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Abstract

We focus on one of the direct metal-polymer joining techniques, Injection Molded Direct Joining (IMDJ). IMDJ initially creates small textures on the metal, allowing molten polymer to infiltrate these via injection molding. The joint can be finish after polymer solidified. This technique can effectively reduce the cost and number of processes. Hot water treatment (HWT), which immerses the metal for several minutes, can form nanoscale structure on metal surface via chemical response. HWT is appealing in aluminum-polymer joining due to its efficiency and performance. However, the oxide layer removement process before HWT, which uses chemical reagents, prohibits it attract attention from industry. A chemical-free alternative is sought. In this study, we propose to use heating process, which has no chemical usage, to replace the oxide layer removement process before HWT. The research studied the effects of heat process conditions before HWT on the joining strength. The results show the heat process (450℃ with 10 minutes) can achieve the same joining performance compared to the oxide layer removement process. In addition, the underlying mechanisms are analyzed through SEM surface observation and XRD analyzation. The results clarified the heat process can help the formation of hot water treated structure.

Keywords: Polymer-metal direct joining, hot water treatment, heat effect

ASPEN2023P_119

Development of Automatic Mold Repair System Using Directed Energy Deposition -Automatic Detection of Cracks on Mold-

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Abstract
Although molding is a useful process for producing a large amount of products at once stably with low costs, wear progress and crack initiation are still remaining as challenges for using the dies sustainably. To repair the damaged molds, a crack detection technique is strongly demanded because the invisibly-small cracks also unexpectedly lower the surface quality of formed products. To detect the cracks on molds, p enetrant inspection is one of the effective approaches. This method facilitates crack detection by visual observation through the contrast between the cracked area and the surrounding area. In this study, the penetrant inspection method is applied to samples with cracks, and an image processing to detect the cracks automatically from the obtained surface picture. The experimental results show that the cracks were successfully detected even if the cracks are on a curved surface.

Keywords: Additive Manufacturing

ASPEN2023P_154

Investigation on Fog Defect of Molded Glass Lens

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Abstract

Precision glass molding (PGM) is the dominant mass-production technology of aspheric glass lenses. The development of high-precision optical systems puts forward strict requirements for the surface quality of lenses, and a homogeneous surface without defect is in demand. However, PGM tends to leave fog defects on the molded glass lenses owing to the complex forming conditions, which affected the optical performance of lenses and reduced the yield rate of industrial production. Few existing studies have focused on this issue, and the characteristics and generation mechanism of the fog defects have not been thoroughly revealed. In this paper, systematical studies on the fog characteristics and its generation mechanism were carried out. The morphology and composition of fog defects was analyzed in detail. The mechanism of the fog defects was successfully revealed considering the interference properties between glass and mold under the PGM conditions. The experimental and analysis results are helpful to understand the essence of fog defects deeply and provide an effective guidance for molding glass lenses with high surface quality in the future.

Keywords: Precision glass molding, Lens, Fog, Defect

ASPEN2023P_093

Automatic Tuning of a Hyperparameter for Autonomous Parameter Exploration in Roll-to-roll Heating System

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Abstract
Controllability of the temperature distribution is required in roll-to-roll heating systems such as an ink application and drying processes of batteries and fuel cells. The conventional experiment approach is inefficient and time-consuming due to a large number of trial-and-error experiments. Therefore, this study was conducted using Bayesian optimization, which requires a small number of trials to find the optimal values [1]. Although the Bayesian optimization realizes autonomous exploration, humans should define many of the parameters such as parameter space, number of trials, and objective functions, which are so-called hyperparameters. In this study, we focused on the parameter called length_scale [2] among the hyperparamers, which has a large impact on the success/failure of the exploration. We designed and constructed the model system as shown in Figure 1(a), and found the cases in which the search fails. In the cases, the prediction range is too wide or too narrow. Then, we developed an algorithm that automatically tunes length_scale so that the prediction range is in appropriate range. Using this algorism, it was demonstrated that length_scale was successfully explored without failure as shown in Figure 1(c) compared to the failure case as shown in Figure 1(b).

Keywords: Bayesian optimization, Gaussian process regression, Hyper parameter, Roll-to-roll, Autonomous exploration

Day 3, 24th Nov 2023 (Friday)
Time: 09:15-11:00

Non-traditional Machining (I)
Venue: Room 1

ASPEN2023P_168

Parameters Optimization for Low Residual Strain and High Manufacturing Speed for Polypropylene Material During Laser Drilling

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Abstract
In modern manufacturing and engineering, residual stress control and detection are essential technologies. Residual stress has a significant impact on the mechanical properties of processed products, affecting their precision, shape, and overall quality, safety, and longevity. This study aims to integrate a laser drilling machine (LDM) with photoelastic effects (PEs) system to determine the residual stress of polypropylene substrates after drilling and manufacturing. We measure the photo-elasticity effect of the specimens with a self-built system for measuring the full-field distribution of fringes. In the process, we collect huge amounts of data to determine fringe distribution. The work utilized a self-developed PE system that collected parameters during manufacturing and yielded quantitative sensor fusion results that can be used to optimize low residual strain and high manufacturing efficiency for polypropylene material during laser drilling. This study comprises three parts: The first part examines the detection of stress in laser drilling using high-precision UV laser machines to measure strains at drilling points and determine processing stress. Second, parameterized designs based on orthogonal tables are utilized to obtain statistical information with minimal trials while considering cost and precision. Lastly, a Photoelasticimeter is used to capture images of photoelastic fringes for optical strain analysis. These images are analyzed alongside processing stress, quantifying residual stress corresponding to fringes, and exploring photoelastic measurement's potential for laser drilling. Through the integration of these principles, a unified system is developed for optimizing process parameters, improving product quality, and lowering production costs. Among the benefits of this work are improvements in experimental efficiency, reduced costs during the experimental phase, and a reduction in the cost of raw materials, time, and labor for digital manufacturing (DM).

Keywords: photoelasticity, laser drilling, measurement, optimization, residual strain, digital manufacturing

ASPEN2023P_088

High Precision Grinding of Large-aperture Aspherical Surface Based on Medium-low Frequency Error Suppression Method

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Abstract

The demand of large-aperture aspherical optical components is increasing dramatically in the fields of space high-resolution imaging, photoelectric targeting, and aerospace as well. Taking the cost into consideration, the processing cycle is required to be shorten, such as 2-3 months for a meter-level large-aperture aspheric mirror. Precision grinding is capable of removing hard-brittle optical materials with high efficiency, but the medium-low frequency error of ground surface can seriously increase the subsequent polishing cycles, which is therefore the objective to be suppressed in this paper. In order to suppress the low frequency errors (form error), the action laws of four main influence factors in terms of the relative position error between workpiece and grinding wheel, the radius error of grinding wheel, the grinding path planning and error compensation have been investigated with the synthetic optimizing of these factors. Moreover, since the grinding texture is primarily contributed to the medium-frequency error (surface waviness) of the ground aspherical surface, the kinematics analysis and homogenization optimizing of the grinding marks are correspondingly studied. According to the verification experimental results, the medium-low frequency error suppression method can either effectively reduce the medium-frequency waviness, or greatly improve the surface figure accuracy (peak-valley value) to be within 3.2μm for an off-axis aspherical mirror of 560mm diameter.

Keywords: Precision grinding, Aspherical surface, Surface quality, Middle frequency error, Low frequency error

ASPEN2023P_188

Study on Machining Quality of Aluminum Honeycomb in Ultrasonic Cutting by Straight-blade Knife

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Abstract

Aluminum honeycomb has been highlighted in aeronautics and astronautics in the form of the sandwich structure, but defects are easily generated during machining. Ultrasonic cutting for honeycomb material has received growing attention over the past years for improved machining quality and efficiency. However, ultrasonic cutting for aluminum honeycomb by straight-blade knife is usually accompanied by cell wall deformation, which results in poor machining quality. In order to support the industrial application of the ultrasonic cutting for aluminum honeycomb by straight-blade knife, a finite element (FE) model is established and experimental investigations are conducted to study the influencing factors of the cell wall deformation. Based on the FE model and experiments, the influence of the blade-inclined angle of the straight-blade knife is analyzed. Moreover, cutting force, the stress in the cutting zone, and cell wall deformation at different cutting parameters are investigated. Results show that the cell wall deformation is significantly suppressed when cutting with a corresponding blade-inclined angle and a lead angle. Meanwhile, the cutting forces decrease significantly with the application of the ultrasonic vibration and increase with the increases in the feed speed. Therefore, a better machining quality can be obtained by cutting with a larger ultrasonic amplitude and a lower feed speed.

Keywords: Aluminum Honeycomb, Ultrasonic cutting, Machining quality, FE model

ASPEN2023P_137

An Investigation on the Effects of Feature Size in High-frequency Ultrasonic Vibration-assisted Sculpturing of Microlens Array

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Abstract

Ultrasonic vibration-assisted cutting (UVAC) is an effective method to fabricate 3D micro-structured surfaces on steel mould for mass production of optical components by hot press forming technology. To fabricate microlens arrays with small feature sizes on steel workpiece, high-frequency ultrasonic vibration-assisted sculpturing (HFUVAS) was used and the effects of feature sizes of microlens array were investigated. A circular target line with one list of lenslets was machined under various machining parameters, and the form accuracy as well as surface morphology was analyzed in order to optimize machining parameters. Moreover, theoretical form error in HFUVAS of lens arrays with various feature sizes was calculated to evaluate the technical feasibility and select the appropriate geometric sizes of lens arrays for HFUVAS. Then, the optimized machining parameters were applied to machine microlens arrays with lenslet radii of 1 mm and 0.1 mm. Results showed that HFUVAS by one cut is feasible in fabrication of microlens array with micro feature sizes. A form error within 1 μm and surface roughness with an arithmetical mean height S_a of below 10 nm were achieved. However, with the decrease of feature size, plastic burr generation and material elastic recovery appeared and resulted in poor machining quality.

Keywords: Ultra-precision machining, High-frequency ultrasonic vibration-assisted sculpturing, difficult-to-machine materials, microlens array, feature size

Metrology (III)
Venue: Room 2

ASPEN2023P_052

Development of Ultra-high Groove-density Grating by Ultrarapid Electron Beam Lithography for Full-field X-Ray Spectromicroscopy

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Abstract
X-ray spectromicroscopy is capable of visualizing the internal structure and chemical state of samples with high spatial resolution. The method has been widely applied as an essential technology in a wide range of fields, especially in materials science. With full-field X-ray spectromicroscopy, we can realize high-speed microscopic imaging of ultrashort phenomena in complex materials and devices.
In this study, we develop a multi-aperture grating for a novel full-field X-ray stereomicroscopy system. This device has multiple apertures, each with a variable line-space grating. Using these gratings, we can measure multiple spectra corresponding to different spatial positions in the sample simultaneously. The short wavelength of X-rays requires an ultra-short grating spacing. We fabricated the grating with an ultrarapid electron beam direct writing machine. By controlling the groove periods precisely, we can measure spectra from non-monochromatic X-ray beams with high energy resolution.
In this presentation, we will introduce the design and fabrication process of the multi-aperture grating in detail and show the results of an imaging experiment at SPring-8 BL07LSU.

Keywords: Multi-Aperture Grating, Variable Line Spacing, Electron Beam lithography, X-ray mirror, X-ray Spectromicroscopy, Synchrotron Radiation

ASPEN2023P_025

Deep Groove Measurement Using Broadband Optical Frequency Comb Scattering Spectroscopy

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Abstract
We have been developing a method for measuring fine surface topography over a large area with high accuracy using laser inverse scattering. Laser inverse scattering is a method for measuring surface topography with a dynamic range on the order of sub-micrometers by illuminating a monochromatic plane wave perpendicular to the target surface and retrieving the phase distribution of the reflected light. The purpose of this study is to extend the dynamic range of laser inverse scattering to the micrometer range. However, multiple transverse electric (TE) modes are generated in the groove whose depth is deeper than the incident wavelength, and the phase distribution does not reflect the surface topography. Therefore, we have developed a laser inverse scattering using a broadband optical frequency comb as a light source to correct the phase value by identifying the TE mode from the phase values at multiple wavelengths. In this paper, we confirm the validity of the phase correction method by measuring a 2 μm deep groove. This method makes it possible to measure shapes with micrometer depths with higher accuracy.

Keywords: Laser inverse scattering, Optical frequency comb, Surface topography measurement

ASPEN2023P_111

Enhanced Measurement Technique for Lens Centering Error with Power Analysis and Subwavelength Grating-patterned Prism Module

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Abstract

This study presents a technique for accurately measuring the centering error of a lens. The proposed technique int egrates power analysis, employing a prism module patterned with a subwavelength grating, in conjunction with a reflection-centering system utilizing the −1st-order rays at 5 mW and 650 nm. By leveraging Snell's law and diffra ctive characteristics, the centering error is thoroughly tested and analyzed using a power meter. Compared to the conventional autocollimation-based centering error measuring system, the proposed technique demonstrates a fourfol d amplification in the resolution of optical centering error within the system. The introduced technique in this stud y enhances instrument sensitivity by exploiting variations in the direction and energy of light.

Keywords: Lens centering error, Subwavelength grating, Power meter

ASPEN2023P_030

Performance Evaluation of On-machine Measurement Software

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Abstract

In order to perform on-machine measurement using a touch probe on machining centers, it is necessary to create an NC program, just as an NC program is required to command the cutter path during machining. However, the macro program provided in the machine tools can only measure simple shapes such as the width of grooves and the inner and outer diameters of circles. In recent years, measurement software that automatically generates NC programs has become widespread. In this study, two types of measurement software were compared. The workpieces to be measured were those listed in ISO 10791-7:2014. These measurement software are intended for contour shape measurement on a machining center, and can output the difference between the coordinate values of the measurement points specified on the 3D model and the actually measured values. By using these measurement software, it was found that inspections that cannot be measured by macro programs can be performed.

Keywords: Machining center, On-machine measurement, NC program, accuracy

ASPEN2023P_104

A Broadband Spectrometer with Enhanced Spectral Resolution Using an Off-axis Elliptical Zone Plate

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Abstract

High-performance spectrometers such as Schwarzschild, demand meticulous optical alignment due to the use of convex aspherical gratings and 3-4 non-axisymmetric, aspheric optical components to enhance spectral resolution and aberration performance. Additionally, the widely used Czerny-Turner spectrometer based on a plane diffraction grating has limitations in reducing its size due to the number of optical components involved. It also suffers from astigmatism caused by incident beam with off-axis. In this study, an off-axis elliptical zone plate is proposed as an alternative to address the challenges of miniaturization, aberrations, and alignment issues. An incident beam on the EZP forms different focal

positions depending on the wavelength. This characteristic allows the EZP to serve as a grating, a focusing mirror, reducing the number of optical components and thus the size of the spectrometer. The design process of the diffractive element was carried out using a ray tracing tool, with design parameters including focal length, incident angle, wavelength. The generated pattern was then converted into a binary zone plate that can be easily fabricated. To verify the converted pattern, we simulated this pattern with FDTD method. Based on the design, the pattern was fabricated and utilized in experiments with a SWIR camera. The focal positions were measured according to the wavelength, and the intensity of each light was compared with the OSA data.

Keywords: Off-axis elliptical zone plate, First order diffraction, Binary zone plate, Astigmatism, Finite-difference Time-domain

High speed and Precision Machining (II)

Venue: Room 3

ASPEN2023P_144

Bi-telecentric Phase Measurement Deflectometry for Optical Elements Quality Control

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Abstract
Typical phase measurement deflectometry (PMD) measurement setups with Bi-telecentric lenses are studied in this paper. Unlike the non-telecentric imaging system, the Bi-telecentric imaging lenses can be employed to provide a nearly constant magnification in working distance. Compared with the PMD using the pinhole imaging model, the proposed Bi-telecentric phase measurement deflectometry (BT-PMD) has less parameters to be involved in the calibration routine and the reconstruction process, which means that a more robust calibration result and a more accurate measurement result can be achieved. Subsequently, a flexible calibration procedure for Bi-telecentric stereo phase measurement deflectometry (BTS-PMD) using a planar mirror is proposed, which has the ability to solve the problem of sign ambiguity in the telecentric camera rotation matrix recovering. In the transmitted wavefront measurement, the BT-PMD also has the capability of analyzing the performance of optical elements in an easier measurement process than the traditional active deflectometry based on the non-telecentric imaging system. The experimental results show that the BT-PMD for the optical elements can achieve micron-level accuracy, and distinguish nano-scale scratches and defects as well.

Keywords: Phase measurement deflectometry, Telecentric camera, Freeform, Measurement

ASPEN2023P_042

Vibrational Monitoring and Analysis of Tool Wear Mechanism in High-speed Micro-grinding

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Abstract
Tool wear monitoring and prognosis through real-time data acquisition is imperative in improving the surface finishing quality and reduction of the downtime needed for tool replacement. At the same time, there is a growing demand for the high-speed machining of brittle materials such as ceramics. Previous studies on the real-time tool-wear monitoring with vibrational features focus on low-speed cutting, while such attempt in high-speed grinding of brittle materials were not investigated. This study investigates the wear mechanism of the electroplated diamond tool and the corresponding change in vibration features during grinding. With the experiment performance, the detaching and breaking of grits can be connected to the change in normalized harmonic components of the tool vibration during grinding. The vibration-wear database for grinding tool is then established with experiments over full tool life.

Keywords: Precision machining, Grinding, Vibration, Tool wear, Diagnosis

ASPEN2023P_152

Ultra-precision Machining of 95W-3.5Ni-1.5Fe Alloy by Ultrasonic Elliptical Vibratory Turning

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Abstract
High density tungsten alloy (95W-3.5Ni-1.5Fe) is used in calibrator for precision physics experiment because of its excellent properties. However, tungsten alloy, as a ferrous metal, is difficult to machine using single point diamond turning (SPDT) due to severe tool wear. Thus, in order to realize the ultra-precision machining of tungsten alloy, this study proposed to introduce elliptical vibration into SPDT to retard the tool wear by changing the tool-material contact state and cooling state. The results showed that compared with SPDT, ultrasonic elliptical vibratory turning (UEVT) realized the improvement of tungsten alloy surface roughness Sa from 0.9 μm to 43 nm, the transformation of the machined surface from crushing to nearly damage-free and the reduction of subsurface metamorphic layer thickness from 18 μm to7 μm. In addition, compared with SPDT, the tool life processed by UEVT was extended by 3 times. This study provides a technical reference for the ultra-precision machining of ferrous metals.

Keywords: Non-traditional machining, Ferrous metal, Surface formation, Tool wear

ASPEN2023P_160

Fabrication of the Aspherical Mold Inserts by the Laser-assisted Turning

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Abstract
Binderless tungsten carbide (BTC), as the mold insert material, is widely applied in the field of optical components due to its excellent thermal stability, high wear resistance, and superior chemical resistance. However, the ultra-high hardness significantly affects its machinability, particularly when machining the aspherical surface. To address this issue, this study proposes a laser-assisted diamond turning method to enhance the machinability and surface quality of the BTC. Experimental results showed an aspheric surface with high machining quality was fabricated on BTC surfaces. The characterization results showed the average surface roughness Sa and Sz obtained by the laser-assisted diamond turning method are 1.2 nm and 31.5 nm, respectively. The comparative experiment using traditional single-point diamond turning shows the laser-assisted diamond turning method reduces the surface roughness Sa and Sz by 40% and 37.4%, demonstrating its effectiveness. Therefore, this paper provides an effective machining method for fabricating high-quality aspherical mold inserts, which can be applied in the manufacturing of optical components in the future.

Keywords: Binderless tungsten carbide, Laser-assisted diamond turning, Aspherical surface, Microstructure array, Surface roughness

ASPEN2023P_071

Numerical and Experimental Investigation of the Form Maintainability of Structured Array Surfaces in Maskless Fluid Jet Polishing

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Abstract
Structured array surfaces (SAS) can achieve special functions through technical design in different fields such as electronics, optics, and precision molds. To achieve high performance of SAS, it is essential to improve its surface quality by post-processing while retaining high form accuracy. Due to

the small size of the structured surface features, it is hard for the machine tool to contact the surface uniformly and it may inevitably affect the form accuracy of the polishing surfaces. Maskless fluid jet polishing (MFJP) is a promising finishing method due to its superior shape-adaptive capacity even for small-size structures. In this paper, MFJP was utilized to obtain SAS with nanometric surface roughness and sub-micrometer form accuracy. The material removal distribution in the polishing interface was revealed by the abrasive impact information. The effect of jet impinging angle on the form maintainability of SAS was elucidated by computational fluid dynamics (CFD) simulation and validated by a series of polishing experiments. Finally, three strategies were proposed to improve the form maintainability in the MFJP of SAS. This study can provide some theoretical basis for the ultra-precision manufacturing of SAS regarding form accuracy control.

Keywords: Precision machining, fluid jet polishing, structured array surface, form accuracy

Day 3, 24th Nov 2023 (Friday)
Time: 11:15-13:00

Non-traditional Machining (II)
Venue: Room 1

ASPEN2023P_064

Fundamental Study on CO_2 Laser Forming of Carbon Fiber Reinforced Thermoplastic Sheet - relationship between Pulse Waveform and Forming Characteristics -

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Abstract
In recent years, carbon fiber reinforced thermoplastic (CFRTP), which consists of thermoplastic resins such as polyimide resin and carbon fibers, has been developed because of its excellent features such as lightweight, high mechanical strength, low cost, recyclability and post-formability. Then, the CFRTP has been expected to be applied to practical use in many applications. From the backgrounds, it is important to develop a highly efficient plastic forming method for the CFRTP to put it into practical applications. In this study, application of laser forming to the CFRTP was investigated since the laser forming enables the highly efficient plastic forming without a mold. In the previous studies, it had been found that a CFRTP sheet could be deformed by laser scanning process with a CO2 laser since thermal stress on the surface of the CFRTP sheet was generated. Accordingly, the high-efficient laser forming conditions were investigated by considering the relationships between pulse waveforms and forming characteristics. As a result, it was found that a pulse waveform with low peak power and long pulse width was suitable for the laser forming of CFRTP sheet since less thermal damage and larger displacement could be obtained.

Keywords: Laser forming, Carbon fiber reinforced thermoplastic, CO2 laser, Pulse waveform

ASPEN2023P_002

Corrosion-resistant Coating Based on a Composite of Graphene Oxide and Flaky Zinc-rich Epoxy

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Abstract

Metals react with hydrogen and oxygen in the environment, causing corrosion and erosion. Surface treatments like inhibitors, cathodic protection, and anti-corrosives are used to prevent this. Organic coatings with epoxy resin bases are commonly used to provide a barrier against corrosion. In this study, flake and spherical zinc powders were mixed with epoxy resin to produce a homogeneous zinc-rich composite. The orderly arrangement of flake zinc powder can effectively keep the corrosive liquid out; moreover, combined with graphene oxide can improve the effectiveness and life of the physical barrier coating, which can keep the metal surfaces from corrosion. After being dispersed and stirred uniformly, the composite epoxy was coated on the medium carbon steel and then submerged in a sodium chloride solution. The lower corrosion potential and current determined the preliminary corrosion resistance by monitoring the process with an electrochemical workstation for 1 hour. Subsequently, a salt spray test in 24-hour units was implemented to evaluate the life of the corrosion-resistant coating. The corrosion area ratio was calculated via image processing. The results showed that the evaluated coating life is up to 31 years in the atmospheric environment after 744 hours of salt spray test.

Keywords: Epoxy resin, Flake zinc powder, Graphene oxide

ASPEN2023P_126

A Hyper-viscoelastic Continuum Model for Preforming and Consolidation of Woven Carbon Fabric Reinforced Polymers (CFRPs)

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Abstract

The existing multiscale modeling methods for the performance of cured woven carbon fabric composites do not consider the thickness deformation and nonuniform resin distribution during processing of these materials, causing inaccuracy in numerical prediction. To enhance the modeling accuracy, this article presents a hyper-viscoelastic model using one-layer continuum elements to capture mechanics of the composite prepregs during both preforming and consolidation steps of the compression molding process. It can accurately predict the large deformation during preforming, including in-plane tension and shear, and out-plane bending. Moreover, the important thickness change due to in-plane shear before consolidation is also considered. In addition, the model can capture the significant thickness reduction and corresponding compression force during consolidation, which can potentially assist the mold design. To validate the hyper-viscoelastic model, preforming and consolidation simulation for benchmark single-dome and L-shape molds were conducted to analyze the predicted shear angle distribution, part geometry and part thickness after processing. In the future, this model will be utilized to explore the effects of resin flow, curing kinetics and temperature distribution on part performance and ultimately assist realization of the multiscale and integrated modeling for preforming, consolidation, curing and performance of woven CFRP parts manufactured via the prepreg compression molding.

Keywords: Preforming, Consolidation, Prepreg, Finite element method (FEM), Continuum model

ASPEN2023P_116

Piezo Flexure Mechanism for Extending Pulse Repetition Rate Control Range

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Abstract

In this research, we aimed to improve the control range of pulse repetition in a femtosecond laser system by utilizing a piezo flexure mechanism. The mode-locked laser employed a nonlinear amplification loop mirror (NALM) cavity to ensure stable and reliable operation. However, by incorporating a piezo flexure, we were able to achieve a significantly broader control range over the pulse repetition frequency. The piezo flexure, which deforms in response to electrical signals, facilitated quick adjustment of the laser's pulse repetition frequency. Overall, the introduction of the piezo flexure in this study greatly contributes to enhancing the performance of a stable and reliable femtosecond laser pulse train

Keywords: Fiber laser, Polarization maintain fiber, Absolute distance measurement, Femtosecond laser

Metrology (IV)
Venue: Room 2

ASPEN2023P_070
Development of Composite Markers for High-precision Industrial 3D Inspection Systems
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Abstract
This study focuses on the development of markers for high-precision industrial 3D inspection systems that employ camera-based imaging. Previous marker optimizations have demonstrated effectiveness in two-dimensional detection. However, in a three-dimensional inspection context, traditional markers fail to maintain a consistent intensity distribution across varying photographic angles. To overcome this challenge, we propose a novel methodology: the calculation and quantification of deviations between the fitted center and the actual center of markers at different angles.

By determining their plane positions at the detection center from two distinct angles, each marker's three-dimensional detection position is reconstructed. This restoration further allows for accurate positioning and measurement of the detected object in three-dimensional space, enhancing the detection system's accuracy and efficiency. By reestablishing the triangular posture, each marker's detection position is brought closer to its actual position, enabling the calculation of the composite marker's central position based on the triangle's positional relationship.

This study employs a simulation method to compare the detection result deviations between single markers and compound markers. The findings indicate that this methodology effectively optimizes the issue of inconsistent light intensity distribution at different shooting angles. This solution offers an accurate and reliable 3D positioning strategy for the continued development of industrial 3D detection systems.

Keywords: Camera-Based Imaging, Three-Dimensional Detection, Position Reconstruction, Compound Marker Analysis

ASPEN2023P_185
Surface Profile Error Evaluation Method of Machined Honeycomb Cores
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Abstract
Honeycomb cores are widely used in aerospace as the core of sandwich structures. The machined surface is a discontinuous with thin wall structure, which makes accurate profile measurements difficult. The line laser scanning measurement has been effective for high-resolution measurement of thin-walled honeycomb cell walls, but faces severe interference caused by burrs and outliers. In this paper, data segmentation method of each honeycomb cell wall from the whole surface is proposed to achieve to be processed individually. After noise data removal and surface profile data extraction, the remaining data of each honeycomb cell wall are then stitched together to construct the entire honeycomb surface

profile. By matching with the theoretical model, the surface profile error can be computed. This paper gives a complete evaluation method of the machined honeycomb surface profile, which is pragmatic for providing guidance for improving the machining quality of honeycombs.

Keywords: Honeycomb cores, Surface profile error, Line laser scanning, Discontinuous data, Noise data removal

ASPEN2023P_106

Broadband Spectrum Generation Using IR-laser Pumped Laser-sustained Plasma

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Abstract

The generation of high-UV spectral radiance light source is essential for a range of applications in inspection systems, microelectronics, photoemission electron microscopy, and spectroscopy as well as to measure the optical characteristics of materials. In this study, a high-power continuous wave (CW) laser was focused on a Xenon arc lamp to sustain plasma and developed an oblique incident pump laser configuration to optimize the performance of the laser. The results demonstrate that laser-sustained plasma can efficiently generate intense radiation in the broadband range from 200 nm to 2000 nm especially the deep ultraviolet (DUV) range from 200 nm to 280 nm. Also, the oblique incident laser pump configuration shows superiority over other configurations such as having a smaller spot size, higher brightness as well as optimizing laser energy. Our results suggest that LSP is a promising approach for the production of high-UV spectral radiance, with potential applications in a range of fields.

Keywords: Laser-sustained plasma, Xenon lamp, DUV light source

ASPEN2023P_192

Enhancing the Accuracy of Ultra-precision Straightness On-machine Measurements Based on Uncertainty Propagation Law

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Abstract

The Fourier three sensor (F3S) straightness measurement is a promising on machine measurement of the slide error motion by eliminating the influence of the workpiece profile. However in the F3S measurement, the probe spacing deviation deteriorates the measurement accuracy significantly. Up to now, it still lacks an effective method to reduce the influence of spacing uncertainty in the F3S measurement. Thus a novel method will be proposed to improve measurement accuracy in this paper. To get this target, first, the algorithm of the F3S method based on the Laplace transform was reviewed. Then, we theoretically analyzed the adverse impact of the probe spacing deviation. Next, to quantify the influence of the spacing uncertainty, we algebraically derived the spacing uncertainty propagation law based on the partial differential in the S domain. Subsequently, to reduce the measurement uncertainty, a solution of spacing optimization is presented based on the uncertainty propagation law Finally, to validate the effect of the spacing optimization , Monte Carlo simulations were performed . The results show that the derived uncertainty is well agreed with the statistical uncertainty with an error of 0.6 μm (6%). Moreover, the F3S measurement can achieve the smallest uncertainty by the spacing optimization based on the derived uncertainty.

Keywords: F3S straightness measurement, Spacing uncertainty propagation, Monte Carlo method, Spacing optimization

ASPEN2023P_063

Interferometric Profiling of Wafer Surface Using Deep Learning and Two-frame Interferometry

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Abstract
In this paper, we propose a new interferometric profiling method with only two interferograms using deep learning. Unlike traditional multi-frame methods, a silicon wafer can be measured by two-frame interferometry with this method. Instead of using the real interferograms as training datasets, we generate simulation datasets by linear combinations of the Zernike polynomials. Once a network is trained by a large number of simulation datasets, the trained network can predict a phase map from two inputted interferograms in real-time. Experimental results demonstrate its outstanding performance through various metrics, in terms of high accuracy and error compensation over traditional multi-frame methods. It is confirmed that the proposed method using deep learning can measure the surface shape of the silicon wafer precisely with only two interferograms.

Keywords: Deep learning, Interferogram, Interferometric profiling, Silicon wafer, Zernike polynomial

Additive Manufacturing (II)
Venue: Room 3

ASPEN2023P_041

Multi-objective Bayesian Optimization Method for High Strength and Dimensional Accuracy in Thermoplastic Extrusion Additive Manufacturing

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Abstract
Thermoplastic extrusion additive manufacturing (TEAM) is a rapid-prototyping method but is also sometimes used to manufacture final parts for mass-customized products. The parts made by TEAM require high strength and dimensional accuracy; however, these two properties have a trade-off relationship. It requires a lot of time to optimize the strength and dimensional accuracy among the various parameters such as nozzle temperature, nozzle scan speed, and layer thickness. At the same time, it is difficult to find parameters based on the physical simulation due to the complexity of the inciting phenomena. In this study, multi-objective Bayesian optimization (MOBO) is applied to optimize the strength and dimensional accuracy in TEAM. We formed rectangular test pieces with a certain nozzle temperature and layer thickness, then measured the bending strength using a three-point bending test and the dimensional error using a micrometer. After that, the Pareto-front was updated, and the next parameter candidates for the nozzle temperature and layer thickness were suggested based on the two evaluation values. This MOBO system found the parameter-sets that optimize the two evaluation values with 21 initial conditions and 40 searches from a total parameter size of 1944.

Keywords: Fused deposition modeling, Bending strength, Dimensional accuracy, Bayesian optimization, Multi-objective optimization

ASPEN2023P_081

Hybrid Finishing of the Additively Manufactured Tubular Lattice Structure for Medical Application

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Abstract

Additive manufacturing (AM) has shown great potential in creating lattice structures with unique mechanical properties that are difficult to achieve through traditional manufacturing processes. However, the intrinsic surface defects in AM lattice structures can have a significant impact on their properties, including inferior mechanical strength, reduced specific energy absorption, and fatigue life. Therefore, it is essential to improve the surface quality of AM lattice structures to ensure their optimal performance and reliability. Existing finishing methods such as sandblasting, chemical etching, and electrochemical polishing may encounter problems such as inaccessibility to the internal lattice surfaces, uneven removal, or environmental issues. The finishing of lattice structures poses a unique set of challenges due to the fragility of the thin structures and the limited accessibility of conventional finishing tools. Hence, this paper aims to develop a novel hybrid finishing method for AM tubular lattice based on magnetic abrasive finishing and dry electrochemical polishing. Results have shown that the surface finish can be improved by more than 70% and the resultant surface is free from the major defects including the partially bonded particles and staircase effect. This study advances the surface finishing techniques of AM complex structures and provides an alternative post-processing method for the AM industry.

Keywords: Surface finish,, Additive manufacturing, Lattice structure, Magnetic abrasive finishing

ASPEN2023P_010

Research on Mesoscale Modeling and Simulation of Selective Laser Melting Process of Quartz Powder

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Abstract

This research focuses on the impact of material spatters, voids, cracks, and other defects on the quality of the quartz samples obtained by selective laser melting, the analyses of the mechanism of defect formation, and how to effectively suppress the defects generation. ANSYS FLUENT software is used to model and simulate the fluid dynamics during the selective laser melting process of quartz powder and deeply simulates and analyzes the spattering phenomenon of molten droplets during the melting process. The mechanism of internal defect formation in additive quartz samples is explored by studying the effects of different process parameters (laser power, scanning speed, powder layer thickness) on thermodynamic dynamic of molten pool. The spattered particles carry gas and fall into the molten or unmelted zone, causing defects such as bubble voids and cracks in the formed part.

Keywords: FLUENT, numerical simulation, laser additive manufacturing, 3D printing, selective laser melting

ASPEN2023P_103

Investigation of Surface Roughness Effect on Machining Process of Workpieces Deposited by Wire and Arc Additive Manufacturing Method

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Abstract

This paper focuses on the investigation of the effects of the increased surface roughness caused by the Wire and Arc Additive Manufacturing (WAAM) deposition process on the side milling procedure. Due to the high heat input of the WAAM method, the surfaces of the manufactured products tend to have rough quality and different deformations that hinder dimensional accuracy. For the WAAM workpieces to be presented as final products there is a necessity of applying methods such as side milling to remove this kind of unevenness, improving the surface quality of the product, this high surface roughness however, can be a hindrance to the material removal process. It is possible that variances in the quantity of material removed occur during the milling process, and consequently, varying the chip

thickness, affecting not only the cutting forces but also increasing the possibility of occurring chatter vibration and tool breakage. For this investigation then, the effects of the deposited layers and their deformations are studied, being the samples deposited, have their surfaces analyzed via a 3D scanner, and milled for different cutting depths, examining the cutting forces, chatter vibration, surface quality, and linking those results with the samples surface profiles.

Keywords: Additive Manufacturing, Machining, Cutting forces, Arc Welding, Surface Roughness

ASPEN2023P_006

Improvement of Young'S Modulus of the Structures Fabricated by Laser-assisted Electrophoretic Deposition

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Abstract

Recently, three-dimensional micro-fabrication technics have been developed with the increasing demand for microdevices. In particular, additive manufacturing (AM) technics can fabricate complex shape structures. We have developed a unique micro-AM technique using laser-assisted electrophoretic deposition (LAEPD) that combines laser trapping and electrophoretic deposition. This is a simple and inexpensive three-dimensional microfabrication technique. The trapped metal nanoparticles in a colloidal solution by the laser beam are electrophoretically deposited on the substrate. However, it is known that Young's modulus of microstructures fabricated by LAEPD is significantly lower than that of the bulk due to the protective agent in the colloidal solution.

In this study, we developed an in-process annealing method for LAEPD with an additional laser for sintering Au particles to improve Young's modulus. The laser (λ=785 nm), which effectively absorbs and anneals the deposited nanoparticles, was installed separately from the laser (λ=488 nm) with traps the nanoparticles. The deposition by LAEPD and laser annealing processes were alternated in the fabrication. The Young's modulus improvement of the fabricated pillars was evaluated by applying a load using the cantilever of an atomic force microscope. The crystallization of the structure was confirmed by field- emission scanning electron microscopy and electron backscattered diffraction.

Keywords: Laser trapping, Electrophoretic deposition, Nanoparticle, Annealing, Plasmon

Day 3, 24th Nov 2023 (Friday)
Time: 14:00-16:00

Non-traditional Machining (III)
Venue: Room 1

ASPEN2023P_007

Fabrication of Carbon Nanotube Field Emission Tip Array Based on Laser Processing and Research on the Characteristics of Field Emission Array

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Abstract

The floating catalyst chemical vapor method was used to deposit carbon nanotube films, and the catalyst is ferrocene powder. At constant gas volume flow and reaction gas temperature, the height of carbon nanotubes can be changed by controlling the growth time. The proposed carbon nanotube films have good alignment and conductivity and are very suitable for use as a field emission cathode. Then, laser processing was used to fabricate the carbon nanotube needle tip array to improve field emission

properties. We first studied the minimum time required to produce a carbon nanotube film that completely covers the substrate and its corresponding height of carbon nanotubes. After producing a uniform film, we fabricate carbon nanotubes with different laser spacing parameters. For the carbon nanotube tip array, the effects of the laser spacing and carbon nanotube height on the field emission characteristics were discussed.

Keywords: Carbon nanotube, Field emission, Laser processing, Tip array, Chemical vapor deposition

ASPEN2023P_068

Laser-assisted Nanoimprint on Glass Materials and Its Mechanism

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Abstract
Nanostructured glass is expected to be used for various applications such as optical devices, electronic devices, biological devices, micro reactors and solar cells because glass materials have many advantages such as optical properties, electrical properties, gas barrier properties, chemical resistance, weathering resistance, hardness and biocompatibility. Thermal nanoimprinting is one of the major methods used fabricate nanostructures on glass materials [1]. However, conventional thermal nanoimprinting has technical issues like long cycle time and low energy efficiency. Laser-assisted nanoimprinting (LANI) is one of the highest-throughput and highest-energy-efficient replication techniques [2]. Figure 1 shows the schematic of LANI. A laser is irradiated onto the surface of the mold to immediately heat it, and heat conduction partially melts the glass material, thus nanostructures are replicated onto the glass surface. In this study, LANI is demonstrated on low-melting-point glass materials. Figure 2 shows an SEM image of the imprinted nanostructures, a 750-nm-pitch line and space on a glass surface using LANI. However, LANI's rapid heating and cooling process readily causes cracks on the glass surface. The cracking mechanism of the glass by LANI is discussed from the perspective of input energy and the thermal properties of the glass.

Keywords: Nanoimprint, Replication, Glass, Laser-assisted, Thermal Stress

ASPEN2023P_166

Ultra-short Time Meniscus-confined Electrodeposition at Nanoscale

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Abstract
Additive manufacturing, an evolving technology for crafting metal structures, holds the potential to supplant traditional precision manufacturing methods. Within this metal-based additive manufacturing landscape, electrodeposition-based techniques stand out for their ability to produce high-purity nanoscale structures (<100 nm). Meniscus-confined Electrodeposition (MCED), utilizing a nanoscale nozzle-equipped micropipette, offers effective confinement of the electrodeposition region. Nevertheless, the method grapples with nozzle clogging and persistent feature size constraints due to extended voxel deposition times. To address these challenges, we explored ultra-short time meniscus-confined electrodeposition, aiming to curtail deposition intervals for smaller voxel volumes, notably reducing voxel height. This approach holds promise in mitigating clogging and potentially achieving a breakthrough in feature size reduction. Our strategy involved a microcontroller for voltage generation, ionic current signal detection, and prompt electrodeposition termination. In practice, we successfully created a consistent 10×10 array of Cu dots, each approximately 100 nm in diameter, with a rising time of 2-4 ms.

Keywords: Electrodeposition, Meniscus, Nanoscale

ASPEN2023P_028

Micro-transfer-printing of Au Thin-film with Atomic Diffusion Bonding: Effects of Air-exposure Time and Stamp Modulus

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Abstract

This present study describes micro-transfer-printing of Au thin-film with the assistance of atomic diffusion bonding. The Au thin-film, coated on micro-ridges of h-PDMS stamp, is contacted to another Au thin-film previously coated on the substrate. These two Au thin-films are strongly bonded by inter-diffusion of Au atoms, and then the Au thin-film is transfer-printed from the stamp to be formed in a micro-pattern onto the substrate in atmospheric condition. This study is intended to show effects of air-exposure time, contact time and stamp modulus on the transfer printing of line-patterned Au thin-film assisted with atomic diffusion bonding. The longer time of air-exposure make more contamination, adsorbing water molecules, to decrease transfer rate. It is found that both the Au-coated h-PDMS stamp and the substrate need to be kept in dry and low humidity environment before transfer-printing. The modulus of h-PDMS stamp is controlled with the ratio of curing agent. The lower modulus of h-PDMS stamp enables higher transfer rates due to large contact area. It is demonstrated that 150-nm-wide line pattern of Au thin-film is also transfer-printed.

Keywords: Transfer printing, Diffusion, Au thin-film, Air-exposure, Modulus

ASPEN2023P_125

Effect of Crystal Orientation on Micro-cutting Mechanisms of FCC Crystal: Crystal Plasticity Finite Element Simulation

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Abstract

The micro-cutting performance of polycrystals are closely related with the specific crystal orientation of grains, as the material removal in micro-cutting happen at grain levels. To improve the micro-cutting quality, it is important to make clear the machining mechanism of grains with different orientations from the perspective of inherent microstructure and micro-texture evolutions. A crystal plasticity based micro-cutting simulation model has been developed with virtue of user material subroutine VUMAT in commercial software ABAQUS. Three different crystal orientations, including (001), (011) and (111), have been considered. Results show that the machining force, i.e., cutting force and thrust force, and chip topography varies with the crystal orientation. The difference has been explained from the dislocation density, preferred slip systems, and lattice rotation. Besides, the experiment has been performed to verify our developed cutting model.

Keywords: Crystal plasticity, dislocation density, micro-cutting, crystal orientation

Metrology (V)

Venue: Room 2

ASPEN2023P_122

XYθ Displacement Sensor by Four Encoders for Wide and Precise Measuring of Holonomic Robot

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Abstract

Recently, various holonomic mobile manipulators have been proposed, such as omni-wheel, multi-legged, and piezoelectric driven mechanisms. In the piezoelectric driven mechanisms, there are many drive principles, such as stick-slip, inchworm, multi-legged, ultra-sonic, and alternative tripod gait. Most of those piezo-based holonomic mobile robots have holonomic mobility, sub-micrometer resolution, and wide area positioning area, simultaneously. For measuring those mobile robots, researchers usually adapt visual feedback control under microscopy. The visual feedback control has been commonly used method for its ease of operation, however there are tradeoff between the measuring cycle and area. In this paper, we describe compact XYθ displacement sensor composed of four optical linear encoders and an integrated two-dimensional scale for measuring those precise mobile robots with sub-micrometer resolution, fast measuring cycle, wide measuring area, simultaneously. We also discuss future prospect for improving the measuring range in XYθ simultaneously.

Keywords: XYθ displacement sensor, encoders, sub-micrometer, holonomic

ASPEN2023P_109

A PSF-model-based CNN Approach to Enhancing Microscopic Image Resolution

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Abstract
In this study, the trade-off between high numerical aperture and reduced measurement speed in high-resolution optical systems is addressed by proposing a computational method to enhance microscopic image resolution. We present a point spread function (PSF) calibration-based convolutional neural network (CNN), designed to combine the strengths of established super-resolution techniques while mitigating their drawbacks. This model uses a database of measured and parameterized PSFs as its key parameters, aiming to improve the CNN's interpretability and convergence speed. A custom calibration target measures the system's PSF, mapping its distribution along the axial direction. Through experimental validation, our method effectively boosts the optical resolution of a microscopy system with a numerical aperture of 0.8 to a precise 500 nm.

Keywords: Image superresolution, Point spread function, convolutional neural network, precision metrology

ASPEN2023P_165

Film Thickness Measurement by Ultrasonic Atomic Force Microscope

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Abstract
In the contemporary landscape of semiconductor technology and various other fields characterized by the continual miniaturization of device structures, the precise measurement of subsurface features has emerged as an imperative requirement. Traditional detection methods often exhibit inherent shortcomings, including susceptibility to sample-AD155dependent effects and constrained detecting resolutions. To address these challenges, the fusion of Atomic Force Microscopy (AFM) and ultrasonics, known as UAFM, has arisen as a viable solution. This innovative method delivers exceptional resolution and remarkable adaptability across diverse sample types. Within this context, we introduce a novel method that leverages UAFM in conjunction with Finite Element Analysis (FEA) modeling. This method empowers researchers to accurately determine material thickness and predict maximum detectable depths by analyzing amplitude signals. As a result, our method significantly enhances the utility of ultrasonic force microscopy in the realms of subsurface imaging and analysis.

Keywords: Thickness measurement, UAFM, Finite element analysis, Subsurface imaging

ASPEN2023P_031

Investigation of Optimal Conditions in Cube Machining Test on Five-axis Machining Center

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Abstract

The cube machining test is a test method in which each face of a cube is divided into nine parts and each part is cut with a different tool angle using a ball end mill. Compared to the conventional accuracy test method, it can be evaluated without using dedicated equipment, so it is already used in the industry to demonstrate the high accuracy of 5-axis machine tools. However, this test method is currently carried out independently by each company, and no test method has been established. In addition, although the evaluation of machining results is based on the height difference and inclination of the machined surface, it is not clear whether the obtained results are caused by spindle performance, geometrical errors, or dynamic errors.

In this study, existing parameters in the cube processing test is investigated, and examined the influence of these parameters on the processing results. In fact, machining tests were conducted by changing several parameters such as the distance from the center of rotation of the table and the order of machining. The causes of errors obtained from the results are discussed.

Keywords: Five-axis machining center, Accuracy test, Machining, Ball end mill

ASPEN2023P_034

Evaluation of Fine Feed Table Positioning for Non-contact Support Based on the Squeezed-air Effect

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Abstract

The squeezed-air effect autonomously generates air pressures through high-frequency oscillations. We have proposed a novel positioning technique based on the squeezed-air effect to provide support and fine feed using a table under non-contact conditions. For this, a uniquely shaped table with a mortar-shaped bottom cross-section was designed. The table was floated and supported in balance with its weight by applying a pressure to the facing surfaces on both sides of the table bottom, and it was fed finely according to the pressure change at one side of the table. Excitation units were provided with angle adjustment mechanisms for the excitation surfaces. Such angle settings facilitated table support according to the table bottom inclination angle. Generally, the ability of the squeezed-air effect depends on the parallelism between the excitation and facing surfaces. The angle adjustment mechanisms also contributed to the improvement of parallelism. Piezoelectric elements were installed as excitation transducers. The relationship between the excitation amplitude and floating height of the table was examined. Subsequently, table positioning experiments were conducted with a step response. The target feed displacement was several tens of micrometers, and the estimated feed displacement was calculated based on the floating height and compared with experimental values.

Keywords: Element, Squeezed-air effect, Fine feed table, Positioning, Non-contact support, Piezo

Bio / Optical/ Medical Manufacturing and Applications (II)

Venue: Room 3

ASPEN2023P_067

Development of a Novel Deformable X-Ray Mirror Based on a Single-crystal Piezoelectric Elements

Junya Yoshimizu*, Takato Inoue*, Maaya Kano, Sota Nakabayashi, Yoshiki Kohmura, Makina Yabashi and Satoshi Matsuyama
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Abstract
It is relatively easy to freely control light in the visible light range, however, it is well known that controlling X-rays, especially beam size, is extremely difficult even with the state-of-the-art technology. The technique to freely change the size of the X-ray beam is strongly required because it will enable a wide variety of X-ray analyses to be performed with a single system configuration. Previously, bimorph deformable mirrors, which is constructed with lead zirconate titanate (PZT) elements and a mirror substrate, have been developed and successfully changed the beam size. However, the deformable mirrors have critical problems of deformation instability and hysteresis mainly caused by the PZT. To overcome these problems, we developed a novel deformable mirror based on a single-crystal piezoelectric element, which has the advantages of excellent linearity and stability. We have actually developed the deformable mirror and performed X-ray focusing experiments at SPring-8. Consequently, the beam size could be changed by a factor of about 70.

Keywords: X-ray optics, Deformable mirror, Bimorph mirror, Piezoelectric element

ASPEN2023P_097

Separating Glass Sheets Via Mechanically, Selectively Induced Median Cracks

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Abstract
Glass cutting has always been difficult, resulting from the complexity of crack generation and its propagation mechanisms. The authors successfully demonstrate the selective median crack propagation in glass via mechanical scribing followed by initial crack creation. The median crack was propagated only backward toward the scribing direction from the initial crack. The critical outcome is that unfavorable cracks on the cut glass quality, such as radial or lateral cracks, were not generated. The crack propagation speed was ~1 μm/s order, and the depth was ~10 μm in the case of the scribing load of <1 N. The authors confirmed that the scribed glass by this method was breakable only backward direction. The crack propagation mechanism will also be discussed in the presentation.

Keywords: Glass, Median crack, Subcritical crack propagation, Plastic deformation

ASPEN2023P_142

Si/SiC Ceramic Gradient Lattice Part Fabricated by Laser Powder Bed Fusion and Liquid Silicon Infiltration

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Abstract
Silicon carbide (SiC) ceramic materials characterized by low density, high strength, corrosion resistance and excellent thermal stability, are widely used in the manufacture of key components for high-end equipment such as aerospace, chemical industries and semiconductors. As innovation continues in above mentioned fields, the SiC ceramic components used in them are also gradually evolving towards larger size, lighter weight and more complex structure. Gradient lattice structures are of great interest in the field of lightweight manufacturing owning to its advantages such as high specific strength, high specific stiffness, on demand load-bearing, and wide design space. However, the intricate structure and challenging fabrication of SiC gradient lattice structures components, as well as the unclear relationship between ceramic structure and performance, have limited the engineering application of these components. Based on the proposed fabricating method for SiC ceramics

combined laser powder bed fusion (LPBF) with liquid silicon infiltration (LSI), SiC gradient lattice structures specimens with varying gradient control functions (linear, Sigma, and cubic function) and gradient spans (20%, 30%, 40%) along the z-axis were fabricated. Subsequently, the forming accuracy and mechanical properties of specimens were analyzed. The mechanical properties of the components were also predicted based on the layered structure model.

ASPEN2023P_060

The Effect of Surface Roughness on the Sealing Performance of Mechanical Joints with Liquid Gaskets

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Abstract
It is common practice to use various solid or liquid sealing materials to fill gaps and improve the sealing performance, or sealability, of fasteners such as pipes. Among these materials, liquid sealants, also known as liquid gaskets, are particularly effective as they can deform according to the surface roughness of the mating surface, improving the sealing effect due to their fluidity. However, it is crucial to ensure that the mating surface is sufficiently smooth to achieve effective sealing. Although excessive smoothness can increase costs, the optimal surface roughness condition for the sealant remains unclear, making it necessary to establish guidelines.

The objective of this study is to experimentally investigate the relationship between surface roughness and the sealing performance of a liquid gasket. Test specimens were prepared with different surface roughness, such as concentric circles, with varying pitches and depths. The study analyzed the effect of the sealant material, pitch, and depth on the sealing performance of the joint at a constant tightening torque. The tightening test materials included acrylic, and the sealing process was observed using a high-speed camera. Additionally, the study monitored the process of sealant change at regular intervals during the drying process.

Keywords: Liquid gaskets, Surface roughness, Sealing performance

ASPEN2023P_193

Optical Design and Analysis of Micro-grooves Machined by Ultra-precision Machining

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Abstract
Micro-grooves machined by ultra-precision machining technology have enormous potential applications in hydrophobic surfaces with self-cleaning properties. Advanced hydrophobic surfaces not only possess self-cleaning properties but are also capable of being applied into those materials with high transparency such as certain polymers. This paper establishes a simulation model of the optical performance of micro-grooves in terms of light transmittance. Experiments have been conducted to investigate the optical performance of micro-grooves fabricated by ultra-precision machining. Both the simulation and experimental results indicate that the geometrical dimensions of micro-grooves in a certain scale and combination do affect the light transmittance. This research provides a useful design guideline of advanced hydrophobic surfaces with high transparency which can be applied to numerous areas such as windshields, solar panels, and vehicle rear mirrors.

Keywords: M icro structures, Ultra precision machining, Optics, Self cleaning

Abstracts for Poster Presentation

Abstracts for Poster Presentations

Additive Manufacturing

ASPEN2023P_037

Surface Quality Control of Holes with Overhang Features in Additive/Subtractive Hybrid Manufacturing

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Abstract
Selective laser melting (SLM) based additive/subtractive hybrid manufacturing (ASHM) enables near-net shaping of complex parts with good surface quality. Hole with overhang features is a typical structure in the complex parts. However, it is difficult to improve the internal surface quality for the holes with overhang features due to the constraint of the three-axis milling in the SLM-based ASHM. This study investigated the surface quality control of overhang holes in ASHM process. An ASHM experiment was conducted to fabricate holes with different overhang angles for GH3536. The depth of sinkage was used to evaluate the ASHMed surface quality. A shielding height method was proposed to protect the machined surface by separating the preceding milled surface from the current melting layer. The result shows that the sinkage occurring at the alternating interface deteriorated the surface quality of overhang holes in ASHM. The shielding height was proved to be effective at the surface quality improvement for overhang holes in ASHM process. This study could provide guidance to the surface quality improvement of complex parts in ASHM process.

Keywords: Additive/subtractive hybrid manufacturing, Selective laser melting, Internal surface of holes, Overhang angle, GH3536

ASPEN2023P_113

Fabrication of Ti-6Al-4V Contouring Structure by M3Dpen Process

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Abstract
In general additive manufacturing, when the upper part of the thin wall is widened or has a three-dimensional structure, there is a problem that collapse occurs at the outer edge. If an outer contouring structure is fabricated on such a structure, collapse can be prevented. Using the M3DPen process, which allows continuous stacking without solidifying the molten metal through volume control of the molten metal during the WAAM process, struts can be manufactured quickly and with excellent rigidity. In order to fabricate the contouring structure, high accuracy of the strut shape and lamination methods in various lamination directions must be devised. Therefore, in this study, in order to obtain high accuracy of the strut shape through the M3DPen process using TI-6Al_4V, struts are manufactured under various process conditions to optimize process parameters, design stacking methods in various stacking directions, and finally create a contouring structure using TI-6Al_4V.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2019R1A5A8083201).

Keywords: WAAM, M3DPen, Lattice Structure, Node bonding

ASPEN2023P_117

A Study on Remanufacturing of Irregularly Damaged Part of the Old Planner Miller Using a DED Process

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Abstract

In order to achieve carbon neutrality in the manufacturing area, research on remanufacturing of mechanical parts using the additive manufacturing process is being actively pursued. Among various additive manufacturing processes, the directed energy deposition (DED) process is most applied to remanufacturing of mechanical parts. The aims of the presentation are to investigate remanufacturing methodology irregularly damaged part of the old planner miller using a DED process. This research work is focused on the development of remanufacturing methodology for ATC (automatic tool changer) parts. Threedimensional scanning was used to obtain geometry data with damaged regions of the ATP part. Considering the damaged region and the failure pattern of the ATC part, the substrate with the engraved region and the deposited shape on substrate are designed. The deposited region is fabricated by DVF-8000AML of DN solutions Inc.. Post-processing is performed to obtain the desired shape of the ATC part. Through several experiments, characteristics of the remanufactured parts are investigated.

Keywords: Directed energy deposition process, Remanufacturing, Old planner miller, Irregularly damaged part

ASPEN2023P_131

Advancing Direct Writing of Elastomeric Fiber for Engineering Meso/Micro Devices

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Abstract

The remarkable capability of direct writing 3D printing techniques to fabricate intricate architectures has contributed to its utility in multiple fields. This technique can be compatible with various materials in types of inks, greases, or pastes. The layered deposition of fluidic materials forms highly complex topography in 3D space, where the deposition method can be digital printing, spraying, or jetting. In some time, external physical stimuli like electrical, magnetic, ultrasonic, etc. can further improve functional device structure design. Herein, we are going to report our efforts to control high–fidelity 3D building of meso/microstructure through process and material improvements. As a result, the same structure performs very much different performance in consideration of mechanics and electricals. More notably, in our latest work, the encompassing arrangements of fibers and the creation of hierarchically organized structures ranging from nanoscale fiber orientations to macroscale dimensions make it promising for a wide range of applications in fiber-based soft meta-components. We will finally update our new results regarding technical applications in fabricating micro/nanofluidic-based sensor networks.

Keywords: Additive Manufacturing, Printed Devices, Meta Materials, Process, Materials

ASPEN2023P_164

Enhanced Mechanical Performance of Laser Additive Manufactured Tix-AlCoCrFeNi2.1 High Entropy Alloys

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Abstract

TixAlCoCrFeNi2.1 (where x = 0, 0.15, 0.3) eutectic high-entropy alloys (EHEAs) were synthesized using the Laser Energy Net Shaping (LENS) technique. The effects of minor Ti additions on the microstructural characteristics were examined utilizing scanning electron microscopy (SEM), accompanied by tensile testing to assess mechanical properties. The findings demonstrate a morphological transition in the microstructures from lamellar to petal-like configurations as distinct Ti contents are incorporated. Concurrently, an augmentation in Ti content leads to a progressive enhancement in ultimate tensile strength (UTS), albeit with a marginal reduction in elongation. Notably, the Ti0.15AlCoCrFeNi2.1 alloy produced through LENS fabrication exhibits a favorable synergy between UTS (1420 MPa) and satisfactory ductility (8%), thereby providing valuable insights for the optimization of high-entropy alloy design.

Keywords: Laser Additive Manufacturing, Mechanical Performance, High Entropy Alloys

Atomic and Close-to-atomic Scale Manufacturing (ACSM)

ASPEN2023P_121

Atomic Scale Polishing of $LiNbO_3$ Crystal by a New Chemo-mechanical Slurry

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Abstract
Lithium niobate (LiNbO3) crystal, known as the ‘silicon of photonics’, has been widely used as an ideal optical waveguide material in producing advanced photonics and nonlinear optics owing to its excellent piezoelectric, nonlinear optical properties and photovoltaic effect. However, the low hardness and fracture toughness with strong mechanical anisotropy of LiNbO3 crystal bring extreme challenges in obtaining ultra-smooth surface of LiNbO3 crystal cost-effectively. In this study, a new graphite oxide (GO) nanosheet added potassium hydroxide (KOH) based silica slurry was developed for close-to-atomic polishing of LiNbO3. Except synthesis method of the slurry, both polishing experiments and nanocharacterisation analyses were conducted to reveal the chemo-mechanical mechanism that dominates the material removal of LiNbO3 in nanoscale. Results indicate that the GO nanosheet additive performs a mutual promotion with SiO2 abrasives, citric acid and KOH, which can significantly improve the dispersibility and stability of KOH-based silica slurry. In addition, the accumulation of KOH-deprotonated GO/SiO2 nanosheets provide an effective tribo-lubricating-film to reduce the friction coefficient at local polishing area. Ultra-smooth surface finish (Sa ≤ 0.15 nm) has been achieved at a material removal rate of 170.0 nm/min on both a four-inch wafer and a triangular prism.

Keywords: Polishing, Material removal, Close-to-atomic scale manufacturing

ASPEN2023P_143

Influence of Point Defects on Ultrashort Laser Pulse Interaction with Silicon: Enhancing the Atomic Layer Etching Process

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Abstract
Atomic layer etching (ALE) is a cutting-edge technique with great potential for advancing the production of next-generation nanoelectronics. As ALE progresses through its sequential etching cycles, it gives rise to defects that impact the atomic-scale removal process. In this study, calculations based on density functional theory (DFT) and real-time time-dependent DFT were conducted to explore how these defects influence the laser-induced ALE of silicon (Si) at the atomic level. The results demonstrated that the removal of the modified (chlorinated) Si layer can be accelerated by point defects, reducing the energy barrier and threshold of laser intensity for desorption. Furthermore, the presence of point defects leads to the emergence of additional defect states within the bandgap, which further

facilitate the laser-induced desorption process. This investigation highlights the potential of process-generated point defects in enhancing the etching efficiency, provided that the laser intensity is appropriately controlled.

Keywords: Atomic layer etching, Defect, Laser, DFT, ACSM

Automation, Mechatronics, and Robotics

ASPEN2023P_101

Path Planning and Control of Industrial Robot Arm Using Depth Camera-based Hand Position Recognition

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Abstract
To control robots in industrial sites, the robot is controlled by specifying a path through pendant teaching or a dedicated simulator. This method has the problem of poor real-time responsiveness and flexibility. In this study, we attempted to present a method to control a robot by reflecting the user's movements in real time. To create a path for controlling the ABB IRB6700 industrial robot, we explored the integrated use of Intel Realsense Depth Camera and Openpose. Openpose is a real-time multi-human body pose estimation algorithm that can detect the location of human body feature points on a 2D image, and Intel Realsense collects depth information and converts 2D feature point coordinates into 3D space coordinates. First, the user's location is recognized through a depth camera attached to the robot, and the 3D coordinates of the user's fingertip are acquired at the desired point. This 3D coordinate data is linked with the ROS-based ABB driver using socket communication and used to set the robot's path. Through this, it is possible to create and control a robot path synchronized to the user's hand movements. Through additional research, we plan to consider user safety and the collision problem of robots by creating a path that takes into account the robot and its surrounding environment.

ACKNOWLEDGEMENT
This work has supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(NRF-2023R1C1C1003966)

Keywords: Industrial Robot, Safety, Digital simulation, Vision Sensor, Collision

ASPEN2023P_114

Analysis of Estimable Link Parameter for Accuracy Improvement of 6-axis Serial Robot

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Abstract
The 6-axis serial robots capable of driving 6 degrees of freedom are widely used as industrial robots because they can be applied to a wide range of applications. In order to apply a 6-axis serial robot in a high-precision process that requires high repeatability and positional accuracy, a calibration process to reduce the difference between the kinematics model and the actual system is required. Since it is difficult and expensive for end-users to make changes to the mechanical structure or design, it is reasonable to improve the accuracy of 6-axis serial robots by calibrating the robot link parameters in the kinematic model. This paper proposes a method for analyzing estimable link parameters among the kinematic parameters of a 6-axis serial robot. The estimable robot parameters were analyzed using the robot's kinematic error model, the radius deviation from circular test of double ball-bar measurement system, and the tool center point (TCP) position error model.

Acknowledgement This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(2023R1A2C2003189)

Keywords: 6-axis series, Double ball-bar, Kinematics parameter

ASPEN2023P_156

Sigmoid-curve Interpolator of a 3-UPU Parallel Mechanism Considering Dynamic Models

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Abstract

The 3-UPU type Parallel Kinematic Mechanism (PKM) consists of three sets of identically configured links, which are connected in sequence by a universal joint, a prismatic joint, and another universal joint. The end-effector's motion is controlled by the coordinated movement of three prismatic joints through linear actuators. To prevent excessive acceleration/deceleration changes that could affect machining precision or even damage the machine, this study considers the three-axis jerk limits and motor torque of the 3-UPU mechanism incorporating its dynamic models. An iterative algorithm based on the sigmoid function is proposed to optimize the motion profile of the interpolator.

First, the analytical kinematics of a 3-UPU parallel mechanism is derived to correlate the relationship between linear drives and end-effector coordinates. The inverse dynamics of this mechanism is then derived, yielding the linear thrust of the drive axes and the motor torque. An iterative algorithm is introduced to optimize the motion profile by adjusting the parameters of the sigmoid function. The optimized interpolator not only presents a smooth and continuous motion profile at the end-effector but also keeps the jerks of three link motions and actuator torque within the set limits. Additionally, it maximizes the reduction of total motion time under the limits, fully deploying the performance of this parallel mechanism.

Furthermore, the inverse dynamic model proposed in this work allows the establishment of a feedforward control system for 3-UPU parallel mechanisms that can further enhance its motion performance and stability.

Keywords: PKM, 3-UPU, Inverse dynamics, Sigmoid function, Acceleration/deceleration planning, interpolator

ASPEN2023P_173

Development of Machine Tending Process Reference Model for Automation in Machining Process

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Abstract

Resin Transfer Molding (RTM) stands out as a prominent out-of-autoclaving technique in the mass production of carbon fiber reinforced plastics (CFRP) for crafting high-quality, intricate composite components at an economical. Despite its capabilities, the majority of RTM processes remain manually executed. To optimize the quality and efficiency of the RTM process, transitioning to automation is essential. The preparation of carbon fiber preforms for RTM encompasses sequential stages: carbon fabric cutting, draping, compaction, and ultimately, trimming. Unlike common isotropic metals, CFRP possesses anisotropic characteristics. Additionally, the uncured nature of the preform materials introduces challenges, including compromised cut quality and dimensional precision owing to their inherent low stiffness. Hence, in this study, a robotic ultrasonic cutting system was designed for trimming CFRP preform materials. To evaluate the efficiency and adaptability of the ultrasonic cutting technique on CFRP preform material, systematic experiments were conducted under various cutting parameters, and the outcomes were subsequently analyzed.

Keywords: Machine tending, Robots, Machine tool

ASPEN2023P_175

Connection and Integrated Operation of Heterogeneous Robots for Parts Machining Process Automation

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Abstract
The 6 DOF manipulator is capable of a variety of movements and can pick up materials or parts of various shapes by modifying the shape of the gripper located at the end of the arm. he application of the 6 DOF manipulator has already become a trend in various industries and is playing a role as a major element in improving the completeness of process automation. AMR (Autonomous Mobile Robots) are used in the distribution industry and the manufacturing and service industries and play a role in overcoming space and facility constraints and achieving logistics automation. AMR (Autonomous Mobile Robots) play a role in overcoming space and facility constraints and achieving logistics automation. In this paper, we discuss the construction of a mobile manipulator by integrating a manipulator and AMR into one system and the case of using it to automate the parts processing process of a small company. Despite leading efforts to achieve interoperability between heterogeneous robots, many robot manufacturers are not yet considering this. In order to connect and integrate heterogeneous robots, challenging problems had to be solved, and it was important to find an appropriate agreement between each device.

Keywords: Manufacturing automation, 6 DOF manipulator, Autonomous mobile robots, Mobile manipulator

ASPEN2023P_181

Precision Laser Soldering System Based on Collaborative Robotic Arm

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Abstract
As electronic devices become increasingly miniaturized, the demand for precision soldering of electronic components has grown. Traditional soldering methods face challenges such as positioning, soldering accuracy, and thermal damage when handling these electronic components. To this end, this paper presents a precision laser soldering system based on collaborative robotic arm. Initially, a 6-dof collaborative robotic arm equipped with a laser soldering temperature control system and a five-light coaxial system was utilized to establish the laser soldering robot system. It was modeled using the standard D-H method. An industrial camera was used to determine the accurate position of the laser beam and its corresponding soldering point, supplying coordinate data for path planning. In the Cartesian space, the particle swarm optimization algorithm identified the optimal movement path based on the specified soldering point coordinates and constraints. The movement trajectory was smoothened using a spline interpolation algorithm. Experimental outcomes demonstrate that the repeated positioning accuracy at the end of the robotic arm reaches ±0.02 mm, with a soldering precision of 0.1 mm. Concurrently, the integrated soldering and inspection system showcases an outstanding soldering detection accuracy of 0.05 mm and boasts a seam compensation capability of 0.04 mm. The system's high automation level enhances production efficiency, substituting traditional manual soldering. It holds vast potential applications in the industrial manufacturing sector.

Keywords: Precision laser soldering, Collaborative robotic arm, Path planning, Particle swarm optimization algorithm

Bio / Optical/ Medical Manufacturing and Applications

ASPEN2023P_163

Blood-Repellent Structured Surfaces with Enhanced Hardness Fabricated by Nitrogen-assisted Femtosecond Laser Ablation

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Abstract
Developing superhydrophobic surfaces with excellent blood-repellency and high hardness is of great significance for the biomedical industry. Despite extensive progress, the application of superhydrophobic surfaces in biomedical devices remains challenging due to unsatisfactory anti-blood adhesion properties and poor stability. Here, a strategy composed of nitrogen-assisted femtosecond laser ablation and low surface energy substance modification is proposed to fabricate blood-repellent structured surfaces with enhanced hardness. It is experimentally demonstrated that altering the laser parameters can greatly affect the wettability, hardness, and optical characteristics of the resulting surfaces. By characterizing droplet dynamics and wettability under different harsh conditions, the excellent stability of the blood-repellent structured surfaces is revealed. In addition, we find that the proposed strategy is suitable for fabricating blood-repellent structured surfaces with enhanced hardness on different substrates including stainless steel, titanium alloy, pure tantalum, aluminum alloy, and copper.

Keywords: Femtosecond laser machining, Structured surface, Hardness enhancement, Blood-repellency

ASPEN2023P_169

Optical Properties of Glass with Trailing Indent Cracks During Chemical Etching

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Abstract
In this paper, chemical etching experiments were carried out on two K9 glasses with trailing indent cracks (TICs). The surface morphology of etched TICs and the optical properties of the glass with etched TICs are analyzed firstly. The results show that the transmissivity of the glass with TICs initially decreases and then increases with the increase of etching time. Conversely, the reflectivity initially increases and then decreases. This can be attributed to morphological evolution of TICs during chemical etching. Then, based on the fact that TICs are a series of spaced cracks, a simulation model is developed for determining the optical properties of the glass with etched TICs. The model is validated experimentally. It is found that the model is effective when the light wavelength is large and the TICs are uniformly distributed. This research contributes to improving the optical properties of polished optical glasses by chemical etching.

Keywords: Ultra-precision machining, Chemical etching, Optical properties, Glass, Trailing indenter cracks

Digital Manufacturing

ASPEN2023P_123

Unified CNC Interface Platform for Heterogenous Cnc Systems

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Abstract
Process monitoring is not optional any longer. Most manufacturing companies are willing to adopt the latest technology to maintain their competitiveness, and information technology is considered fundamental among them. CNCs have played a great role in automating machine tools, and recently CNCs are considered rich repositories of process monitoring because they collect and generate the data to control the machine tools. CNC makers block internal data to secure their confidential technology, but they open the non-confidential data to users. However, users are required to develop their own solutions for each CNC because CNC makers provide exclusive APIs (Application Programming Interfaces) to access CNC information. This paper presents the unified CNC interface platform that can communicate with heterogeneous CNCs. A Machine state model is defined by abstracting CNC systems for machine tools and the unified CNC interface platform is developed. Each CNC's communication API is carefully investigated and comprised in the developed platform. The developed platform communicates with any CNC using the connected CNC's own API and can be expanded to any CNC if the CNC provides the communication API. A monitoring system that can collect information on heterogeneous CNCs is successfully developed by using the proposed platform.

Keywords: Precision machining, Cutting force, Carbon fiber, Cutting force

ASPEN2023P_174

A Study on the Current Characteristics of Spindle Motors in Cnc Machining Centers During Processing

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Abstract
The consumption of current by the spindle motor during machining processes via a machining center is closely correlated with machining loads and has been extensively investigated in various research endeavors. This study delves into the current characteristics of the spindle motor to elucidate its relationship with machining load and achieve precise signal acquisition for machining. To capture the current consumption characteristics, current signals collected from servo drive during machining experiments. Furthermore, cutting forces were measured using a tool dynamometer, and spindle load data were obtained from the CNC. These datasets were subsequently compared and analyzed alongside the spindle motor current. The analysis findings revealed a discernible increase in the cutting force signal within the machining zone, while the spindle motor current displayed no significant elevation and, in fact, registered a lower value. Frequency analysis of the current was undertaken, uncovering an upswing in frequency during machining as compared to non-machining conditions. Through the application of bandpass filtering to the heightened machining frequency range and subsequent conversion to RMS values, it became feasible to differentiate the machining state through current, thereby effectively mitigating noise signals associated with low machining loads.

Keywords: CNC, Monitoring, Machining center, Cutting force

ASPEN2023P_177

Cutting State Monitoring Using CNC Signals

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Abstract
Recently, composite materials such as carbon fiber reinforced plastics (CFRP) have recently garnered significant attention from the automobile and aviation industries because of their excellent mechanical properties and low density. As a result, the importance of various manufacturing processes for CFRP parts has been increasing. However, a variety of difficulties in CFRP machining process have been reported. There are various machining defects such as fibers pulled-out and delamination. Particularly,

significant tool wear is one of the most well-known drawbacks. Therefore, monitoring machining state plays a crucial role in improving machining quality and productivity. In this study, CNC-signals-based cutting state monitoring system for CFRP drilling is presented. Real-time information on NC code and motor motion is employed through an industrial communication scheme to monitor operation states such as machining, fast traveling, and air cutting as well as cutting tool condition. From the experiments, the cutting force in CFRP drilling can be successfully estimated using the CNC signals. Finally, it is presented that the cutting tool wear can be successfully monitored in-process. This work was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and future Planning, Republic of Korea (No. NRF-2018R1A2B2009540), the Technology Innovation Program (10053248, Development of Manufacturing System for CFRP (Carbon Fiber Reinforced Plastics) Machining), Korea Institute for Advancement of Technology(KIAT) grant (P0020616, The Competency Development Program for Industry Specialist) funded by the Korea Government(MOTIE).

Keywords: Cutting state, Tool condition, CNC, Industrial communication, Motor torque

High Speed and Precision Machining

ASPEN2023P_003

Investigation of Ductile-brittle Transition Dynamic Behavior of Tungsten Carbide in Laser-assisted Diamond Machining Based on Discrete Wavelet Transform

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Abstract
Laser assisted diamond machining of binderless tungsten carbide is a promising method, which has drawn increasing attention from various fields, such as photonics and life science. This paper experimentally investigates the ductile-brittle transition dynamic behavior of tungsten carbide in laser-assisted diamond machining based on discrete wavelet transform algorithm. Groove-cutting results reveal that the ductile-brittle transition depth increases by 247.20% from 58.37 nm to 202.66 nm with the increase of laser power from 0 to 20W. Cutting force characteristics and groove profile characteristics simultaneously demonstrate the transition of the cutting mode from ductile to brittle. The detail coefficients at level 2 exhibit a distinct characteristic at the ductile-brittle transition point. The trend of the detail coefficients D2 with laser power shows good agreement with the conclusions obtained from the conventional profile data analysis. This research demonstrates the potency of discrete wavelet analysis for ductile-brittle transition dynamic behavior and provides important insights into the material removal mechanism of laser-assisted diamond machining.

Keywords: Laser-assisted diamond machining, Tungsten carbide, Ductile-brittle transformation, Discrete wavelet transform

ASPEN2023P_016

Ultra-precision Cutting Parameters Generation for Material Consistent Removal of Tungsten Alloy Complex Curved Surface Parts

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Abstract
Owing to the excellent physical and chemical performances of the tungsten alloy, tungsten alloy complex curved surface parts are widely used in aerospace, precision physics experiments, and other high-end equipment. While due to the properties of hard and brittle, tungsten alloy is difficult to machine. Since the material removal rate affects the cutting force and the energy efficiency of the machining

process, further affecting the processing quality and energy consumption, this study focuses on the material removal efficiency of the tungsten alloy complex curved surface parts to realize the micro-nano cutting of tungsten alloy complex curved surface. Firstly, through finite element simulation of ultra-precision cutting, the plastic removal mechanism of the tungsten alloy is analyzed. And then, the calculation method of the materials removal rate is proposed for complex curved surface parts single point diamond turning. To achieve the efficient materials removal rate in tungsten alloy complex curved surface parts machining, the processing parameters are generated with consideration of the geometric characteristics of the parts and the stability of machining. This study can realize the uniform materials removal rate of tungsten alloy complex curved surface parts and improve the processing quality of the crucial parts of high-end equipment.

Keywords: Ultra-precision cutting, Complex curved surface, Tungsten alloy, Material removal rate

ASPEN2023P_038

Cutting Characteristics of Cold Worked Steel for High Tensile Strength Steel Forming Dies Tempered To 60Hrc

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Abstract
High tensile strength steel generally refers to iron and steel materials with a tensile strength of 340 MPa or more, and is used in the chassis and exterior panels of automobiles due to its lightweight and high-strength characteristics, contributing to weight reduction and improved fuel efficiency. However, in the forming of high-strength steel, there is a problem of decreased mold life and an increase in the number of manufacturing processes. Therefore, a machining method has been developed where cutting is performed in a high-hardness state through tempering, which is an ideal mold manufacturing method. The purpose of this study is to investigate whether SKD11 and SLD-MAGIC after tempering can be machined with high precision using various cutting conditions with a general-purpose lathe. As a result, it was concluded that the effect of adhesion on the tool's escape surface wear on the finishing surface roughness was low, and the correlation between cutting resistance and finishing surface roughness was small. Moreover, since the maximum height roughness was within the allowable value required for automotive molds at around 1-1.5 μm, it can be said that high-precision machining of tempered SKD11 and SLD- MAGIC is possible.

Keywords: Precision cutting, Cutting force, Cold worked steel, 60HRC

ASPEN2023P_047

Numerical and Experimental Investigation on Spindle Axial Drift Considering Rotation Speed and Manufacturing Error in Ultra-precision Cutting Machining

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Abstract
In ultra-precision machining, the surface topography quality is directly affected by the spindle axial drift. Thus, an error model is developed to analyze the influence of rotation speed and manufacturing error on spindle axial drift both theoretically and experimentally. The nonlinear Reynolds equation is first solved through Galerkin-Successive Over Relaxation finite element method to obtain static stiffness. Subsequently, by adopting the small perturbation method and building vibration model, the axial the time series amplitudes are output. This study is quite meaningful for clearly revealing the influence rule of axial error from the viewpoint of working parameters and manufacturing error. By utilizing the findings, it will be possible to control spindle errors and predicting machined surface errors.

Keywords: Aerostatic thrust bearing, Spindle axial drift, Dynamic performance, Small perturbation, Numerical calculation

ASPEN2023P_146

Influence of Negative Rake Angle for N-BK7 Glass of Laser-assisted Diamond Turning

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Abstract
N-BK7 optical glasses are widely used in optics, biochemistry, and aerospace. However, this optical glass is always the difficult-to-cut material for ultraprecision diamond turning due to its high hardness and low fracture strength. Therefore, in this paper, the machining technology of laser-assisted diamond turning is proposed to process N-BK7 optical glass. Furthermore, in order to obtain the better surface quality, the influence of negative rake angle, -25°and -65°, is analyzed and discussed respectively during laser assisted processing. For the machining results, the surface quality is enhanced obviously when the -65°negative rake angle is used compared with -25°. After machining, the surface roughness is Sa 277nm after -25°negative rake angle, while the Sa 49nm can be obtained in -65° by interferometer measuring technology. In addition, the different shapes of cracks generated are analyzed by SEM measuring with different tool angle. The results show the N-BK7 optical glassed can be machined by laser-assisted diamond turning.

ASPEN2023P_147

Lubrication Mechanism and Machinability of Multi-dimensional Mixed Nano-Lubricant in Ultra-precision Grinding of Binderless Tungsten Carbide (WC)

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Abstract
Binderless Tungsten carbide (WC) is a key material for moulds and tools, and it is close to diamond in terms of hardness and expansion coefficient. It’s excellent properties also bring challenges in ultra-precision grinding technology for WC mould manufacturing. This paper presents a nano-lubrication method, using mixture of 0-D Fe3O4 and 2-D MoS2 nanoparticles as a nano-lubricant for reducing friction in ultra-precision grinding of tungsten carbide. The results showed that tool wear and surface roughness were significantly reduced with the use of nano-lubricant, comparing with dry and MQL grinding. The lower extent of microfracture, micro-holes, and surface defects was also obtained with the use of nano-lubricant.

Keywords: Ultra-precision grinding, machinability, nano-lubricant, binderless tungsten carbide, lubrication mechanism

ASPEN2023P_150

The Application of Knowlege Management: Investigation of Main Themes and Recommendations for Prospective Ultra-precision Machining (UPM)

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Abstract
Ultra-precision machining (UPM) is a highly advanced technique that plays a significant role in the technological community. Its importance has attracted the attention of both academic and industrial partners. With the rapid development of UPM due to technological advancements, it is crucial to define and revisit the current stages and evolution of this technology in order to sustain and advance it further. This study systematically investigates the state of the art in UPM by identifying the four major themes within this field. A thematic network is then constructed, along with a structural analysis, to understand the interactions between these themes and the roles of theme members responsible for these interactions. Additionally, sentiment analysis is conducted to gauge the academic community's feelings

towards these themes, allowing for a focus on areas that require more confidence. Based on these findings, the future perspective of UPM and suggestions for its advancement are discussed. This study provides a comprehensive understanding and review of the current state-of-the-art in UPM technology, utilizing text mining techniques to critically analyze its research content. It also offers suggestions to address the current challenges and enhance UPM development, ultimately benefiting academia and institutions in leveraging this technology for the betterment of society.

Keywords: Ultra-precision machining, Thematic network analysis, Text mining, Sentiment Analysis, The state-of-the-art, Technological evolution

ASPEN2023P_159

Magnetic Field-assisted Chatter Suppression in Diamond Turning

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Abstract

During diamond turning of difficult-to-cut materials, chatter is a severe problem that reduces the machining quality of the workpiece and accelerates tool wear. So, a magnetic field-assisted cutting strategy is developed to suppress chatter in the diamond turning of titanium alloys. The assisted magnetic field affects the tool/workpiece system through the eddy current damping effect, magnetoplasticity, and the enhancement effect of thermal conductivity of the workpiece, improving its stability and suppressing chatter. Diamond-turning experiments with and without magnetic field assistance are carried out under various cutting conditions. The experimental results, which include cutting forces, frequency spectra correlating to the cutting forces, and surface morphologies, indicate that the magnetic field assistance successfully suppresses chatter during diamond turning. The machined surface quality of the workpiece is also effectively improved

Keywords: Chatter suppression, Diamond turning, Ultra-precision machining, Magnetic field

ASPEN2023P_162

High-frequency Ultrasonic Vibration-assisted Diamond Turning of Micro-grooves on Tungsten

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Abstract

This study investigated the feasibility of high-frequency ultrasonic vibration-assisted diamond turning of micro-grooves on tungsten. Machining experiments were performed, and the machined surface features were analyzed. It is found that, compared with conventional turning, ultrasonic vibration-assisted diamond turning can achieve smoother surface and suppression of surface defects. In addition, the surface wettability of the microstructured surfaces was analyzed quantitatively through the contact angle measurement. The contact angle of the circularly micro-grooved surface is smaller than the linearly micro-grooved one. Therefore, the study demonstrates that ultrasonic vibration-assisted diamond turning can be an effective way of producing functional microstructures on tungsten.

Keywords: Diamond turning, Ultrasonic vibration, Micro-grooves, Tungsten, Surface Morphology

ASPEN2023P_178

Fast Fabrication of Si Microlenses Combined with Ultrasonic Elliptical Vibration Sculpturing and In-situ Laser Assisted Diamond Cutting

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Abstract
Single crystal silicon has been widely used in aerospace and optical detection due to its excellent properties. The functional microstructure can furtherly improve the system performance. In the present work, the ultrasonic elliptical vibration sculpturing was adopted to fast fabrication of microlenses on silicon. To avoid tool wear and obtain better surface quality, in-situ laser was added to reduce the hardness of single crystal silicon. Hence, the fabrication of microlenses based on ultrasonic elliptical vibration sculpturing and in-situ laser assisted cutting was proposed. The experimental achievements verified the high precision functional microstructure fabrication with excellent surface uniformity. The structural height of microlenses was 342 nm, which was close to the critical ductile-to-brittle transition depth of cut by applying laser assisted cutting. This novel technology is proposed to manufacture the functional microstructure surface of hard-brittle materials efficiently.

Keywords: Precision machining, Single crystal silicon, Ultrasonic elliptical vibration sculpturing, In-situ laser assisted diamond turning

ASPEN2023P_179

Form Error Estimation in Milling Process Using Monitoring Data

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Abstract
Recently, extensive research has been actively studied for realization of intelligent manufacturing system. The data-driven techniques, such as data analysis and machine learning model, are utilized for various purposed such as abnormal state diagnosis, tool life prediction, and quality prediction. In this paper, we propose a model that uses monitoring signals and on-machine measurement (OMM) results to predict milling quality. We investigate the correlation between the monitoring signals of machine tool and OMM results, and then construct the machine learning model for the form error estimation. The developed model is implemented to tool-offset recommendation algorithm. From the experimental results, the proposed algorithm is effective to obtain a uniform machining quality.

Keywords: Tool offset compensation, Precision machining, Machine learning, Monitoring, On-machine measurement

ASPEN2023P_180

A Preliminary Study on Robotic Ultrasonic Cutting of CFRP Preforms for the Rtm Process

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Abstract
Resin Transfer Molding (RTM) stands out as a prominent out-of-autoclaving technique in the mass production of carbon fiber reinforced plastics (CFRP) for crafting high-quality, intricate composite components at an economical. Despite its capabilities, the majority of RTM processes remain manually executed. To optimize the quality and efficiency of the RTM process, transitioning to automation is essential. The preparation of carbon fiber preforms for RTM encompasses sequential stages: carbon fabric cutting, draping, compaction, and ultimately, trimming. Unlike common isotropic metals, CFRP

possesses anisotropic characteristics. Additionally, the uncured nature of the preform materials introduces challenges, including compromised cut quality and dimensional precision owing to their inherent low stiffness. Hence, in this study, a robotic ultrasonic cutting system was designed for trimming CFRP preform materials. To evaluate the efficiency and adaptability of the ultrasonic cutting technique on CFRP preform material, systematic experiments were conducted under various cutting parameters, and the outcomes were subsequently analyzed.

Keywords: RTM(Resin Transfer Molding), Ultrasonic Cutting, Carbon fiber, Preforms

ASPEN2023P_189

Study on Orthogonal Cutting Force Model of Ceramic Matrix Composites

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Abstract
Carbon fiber reinforced silicon carbide ceramic matrix (Cf/SiC) composites have great application potential in aerospace. However, there are problems in Cf/SiC composites milling due to their high hardness, high wear resistance and anisotropy such as large fluctuation of milling force and poor machining quality. The key to solve the above problems is to establish orthogonal cutting force model of Cf/SiC composites. In this paper, an orthogonal cutting force model of 2.5D Cf/SiC composites considering matrix cutting force, warp cutting force and weft cutting force was established. Orthogonal cutting experiments were carried out to verify the accuracy of mechanical model. The experimental results show that within the range of experimental parameters, the maximum error between the theoretical and experimental values of main cutting force is 12 %, and the maximum error between the theoretical and experimental values of thrust force is 20.7 %.

Keywords: Cf/SiC composites, orthogonal cutting, cutting force model, weft and warp

ASPEN2023P_190

Effect of Wheel Path in Raster Grinding on Surface Accuracy of an Off-axis Parabolic Mirror

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Abstract
Off-axis parabolic mirrors have extensive applications in X-ray optics, with the precision of their curvature directly impacting grazing-incidence focusing performance. Notably, the off-axis parabolic surface has non-rotating and non-symmetrical characteristics. Ultra-precision raster grinding utilizing a diamond wheel is a common method. Crucially, establishing an optimal wheel path stands as the key to ensuring surface accuracy during off-axis paraboloid grinding. In this study, according to the double curvature property of an off-axis parabolic surface, two different wheel paths were compared: one tracing the meridian direction (parabolic generatrix) and the other following the arc vector direction (arc). The results showed that the wheel path in raster grinding stepping along the arc vector direction can obtain a smaller scallop height and higher surface accuracy. The surface accuracy of one step along the arc vector direction is 9.6 μm, and that of the other step along the meridian direction is 32.6 μm. A model of the scallop height was established based on the relative relationship between adjacent wheel paths, and the error is within 5%. According to the correlation between scallop height and shape error, we conducted an analysis of the spatial distribution of shape errors under varying wheel paths. The wheel path that steps along the arc vector is more suitable for raster grinding of the off-axis paraboloid. The above study can provide theoretical guidance for the wheel path planning of off-axis parabolic mirrors with high surface accuracy.

Keywords: X-ray optics, off-axis parabolic, raster grinding, scallop height, surface accuracy

IoT / AI / Big Data in Manufacturing

ASPEN2023P_048

Profile Prediction in Electrochemical Jet Machining by Machine Learning

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Abstract
In Electrochemical Jet Machining (EJM), given experimental parameters, the quantitative prediction of material removal can play a guiding role in industrial applications. The current mainstream Finite Element Method (FEM) for predicting material removal meets great challenges. First, FEM is computationally expensive, which leads to taking tens of minutes to solve a small model. Second, the real machining process is a complex physical process, but FEM usually ignores some secondary factors to simplify the model. Third, the application of FEM requires commercial software, but it is difficult for researchers in the manufacturing field to analyze the reasons for its non-convergence. In this study, the machine learning method is applied to the quantitative prediction of EJM outcomes, which is an end-to-end prediction method without the problems of FEM. Data-driven models are more practical in industrial circles. We conduct practical experiments to obtain training datasets and construct the prediction models using Pytorch. By utilizing this methodology, we aim to develop accurate and reliable predictive models that can effectively generalize and make accurate predictions on machining results under other experiment parameters.

Keywords: Electrochemical jet machining, Quantitative prediction, Machine learning, Data-driven model

Manufacturing Systems and Machine Tools

ASPEN2023P_035

Effect of Cutting Fluid on Surface Processing with Non-rotational Cutting Tool Using Damping Alloy

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Abstract
The purpose of this study is to obtain a high-quality sealing surface by cutting process using non-rotational cutting tool. In the previous study, the effect of suppressing chatter vibration by indexable non-rotational cutting tools using damping alloy was investigated. A commercial cemented carbide tool and a custom indexable damping material (M2052) tool were used in the experiments. Cemented carbide was used for the tip of the indexable damping material tool. The occurrence of chatter vibration was investigated by changing the cutting force with a dynamometer and observing the machined surface with a digital microscope. It was shown that the chatter vibration suppression effect of non-rotating cutting tools using damping alloys is higher than that of conventional non-rotating cutting tools. In this study, the effect of cutting fluid on the chatter vibration suppression effect of non-rotational cutting tool using damping alloy was investigated. As a result, it was shown that low-viscosity cutting fluid is most effective in suppressing chatter vibration in cutting process with non-rotational cutting tool using damping alloy.

Keywords: Sealing surface, Cutting force, Cutting fluid, Chatter vibration

ASPEN2023P_075

Temperature Dependence of Plasma Etching Properties of SiO_2 Using High-pressure Plasma

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Abstract
Quartz crystals are used as clock sources in many kinds of electronic and mobile communications equipment, and their oscillating frequency has increased as the volume of information increases. Therefore, thinner and thinner crystal substrates are required, and thickness uniformity of quartz crystals is more and more important to suppress variations in oscillation frequency. Thus, we aim to realize precision numerically-controlled processing to improve the thickness uniformity of quartz substrates by plasma etching using a high-pressure (atmospheric pressure to a few tenths of atmospheric pressure) plasma with a parallel plate electrodes system. In this study, we focused on temperature as the processing condition and evaluated the removal rate and surface roughness of SiO2 substrates. As a result, it was found that as the processing temperature increased, the removal rate increased, and the surface roughness also improved.

Keywords: SiO2, plasma etching, high-pressure plasma, temperature dependency

ASPEN2023P_089

Fabricating Hydrophobic Pillar Arrays on Brittle Materials Using Laser Structured Grinding Wheel and Integrated On-machine Surface Metrology System

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Abstract
Surfaces with microstructures are increasingly utilised in many fields due to some novel properties such as light modulation, hydrophobicity, and antibiofouling. Generating microstructures with high side straightness on brittle materials is still a challenge. This paper proposes a novel processing strategy to fabricate hydrophobic pillar arrays with nearly vertical sidewall on ceramics using laser profiled diamond grinding wheels. A laser profiling strategy using 2D galvo mirror system is proposed to texture the metal bond diamond grinding wheel with rectangular shapes. Pillar arrays with high height uniformity and straight sidewall are then ground on ceramic surfaces with the assistance of confocal probe based on-machine surface metrology system (OMSMs). Results show that the nanosecond pulse laser marking system is flexible for texturing the super abrasive grinding wheel with self-designed geometry. The integrated OMSMs is useful for improving the height error of ground pillar arrays after twice compensation machining. High side straightness microstructures are manufactured on the ceramic samples and hydrophobic effect is verified through contact angle goniometer test.

Metrology

ASPEN2023P_009

On the Spring Effect of Linear Ball Guides and Its Functions Towards an Ultra-precise Positioning

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Abstract

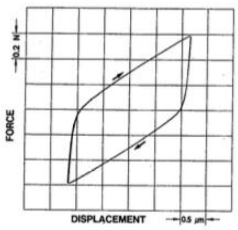

Figure 1. Measured [Force – Displacement] relationship of a linear ball guide (THK LM1530 not having ball retainer), (1990). The inclination of the curve indicates the spring constant. Two spring lines can be seen; 10N/µm and 0.3. A point of inflection existed at 100nm displacement after the direction of the motion was reversed.

Function one:

The spring effect makes a ultra-precise positioning quite easy to be obtained.
For a position reference which bandwidth is under 0.7*the natural frequency $f_n=(1/2\pi)(K/M)^{0.5}$,
the minute displacement Δx is proportional to the force change Δf;
That is $\Delta x = (1/K)\,\Delta f$, where K is the spring constant of the spring effect of linear ball guides.

Therefore, simple controls can be applicable to the ultra-precise positioning,
such as Integral, Proportional and Integral, and PID controls.

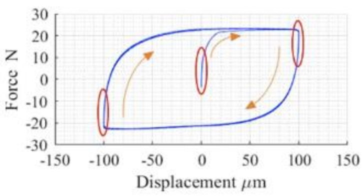

Figure 2. Measured [Force – Displacement] relationship of a linear ball guide (THK SPS25 having ball retainers). The maximum spring constant was 10N/µm.

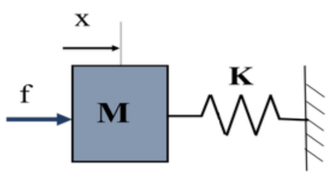

Figure 3. A simple mechanical model of the positioning mechanism, in the existence of the spring effect.
The natural frequency f_n is $\frac{1}{2\pi}\cdot\sqrt{\frac{K}{M}}$ where K: the spring constant and M: the mass of moving part.

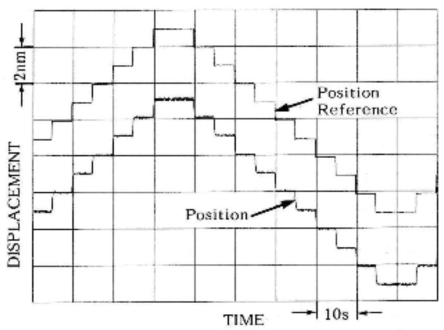

Figure 4. One nanometer step responses of the positioning system (1990).
In this experiment only a simple Integral control was applied. The position was sensed by a high-sensibility analog gap sensor. Guide: THK 1530.

Function two:

The spring effect of linear ball guides outstandingly reject the disturbance force vibrations under the condition of the frequency of disturbance is lower than $0.7*f_n$, where f_n is the natural frequency of the mass-spring model of the positioning system.

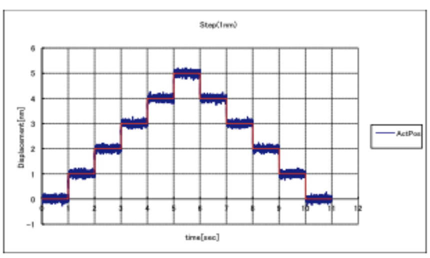

Figure 5. One nanometer step responses of the positioning system.
In this experiment (P, PI) control was applied. The position was sensed by a linear scale whose resolution was 31pm. Guide: THK SHS25.

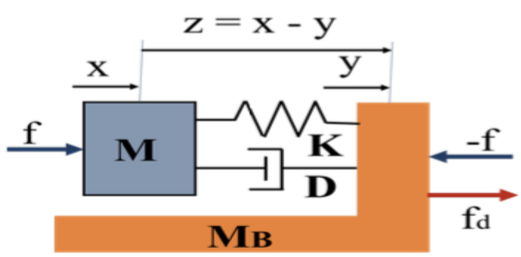

Figure 6. A simple and generalized model of the positioning system.

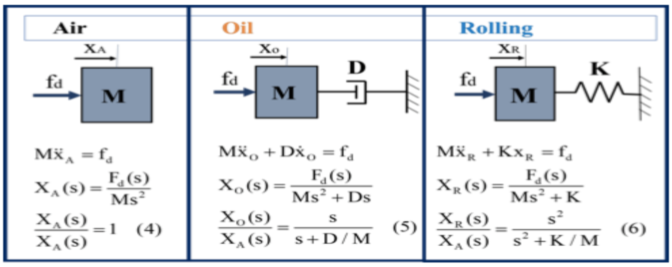

Figure 7. Simplified dynamic model of Air, Oil and Rolling bearing used positioning system.

Figure 9. A working bench (Left) and an air anti-vibration bench (Right).

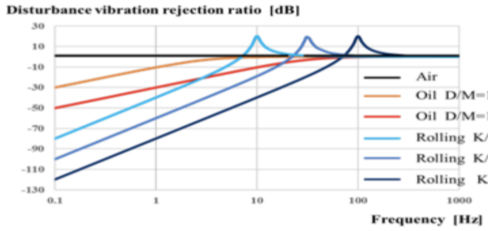

Figure 8. Disturbance vibration rejection ratio for Air, Oil and Rolling bearings.

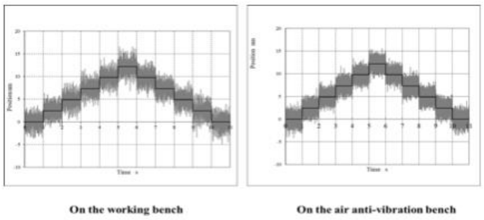

Figure 10. Comparison between the 2.5nm step responses on the working bench and the air anti-vibration bench. The peak-to-peak vibration amplitudes were only 30% differed.

ASPEN2023P_072

High-resolution Multiplexed Optical Spectrometer with Wide Spectral Range

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Abstract

A spectrometer is a device commonly used in many fields of scientific research. In the optical spectrometer, most important features are the spectral resolution and measurement range, i.e. it should measure the spectrum with high resolution in the wide spectral range. A typical spectrometer is of the Czerny-Turner type and consists of a slit, off-axis mirror, a diffraction grating, and a line-array detector. However, this configuration is complex, and causes a limitation of the spectrum range and resolution. To address this limitation, we develop a multiplexed optical spectrometer, which uses several concave gratings to decompose the spectral range of the source, in this investigation. The use of an aberration-corrected concave grating instead of plane grating can eliminate the collimating and focusing mirrors in the spectrometer, and the overall structure of the spectrometer is simplified by the Rowland circle without any additional mirrors. By the combination of a multi-channeled input and various concave gratings, the whole spectral range is fractionized, and each spectrum is obtained as a line in the area camera to confirm the high resolution. In the experiment, the standard wavelength calibration sources were used to match the camera pixels to wavelengths, and the spectral resolution below 0.1 nm in the spectral range from 200 nm to 1,100 nm was confirmed.

Keywords: Multiplexed optical spectrometer, Concave grating, High resolution

ASPEN2023P_073

Optical Sectioning Structured Illumination Microscopy with Improved Lateral Resolution for Micro Pattern Measurement

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Abstract

Recently, semiconductors and display products have been gradually miniaturized, and the circuit patterns are more complicated for multi-functionalities. In the manufacturing process, these products should be inspected to avoid the failure, and high-resolution microscopic technologies need to be developed. For the purpose, confocal scanning microscopes and interferometric microscopes are applied to meet the demands required by industries. However, the conventional microscopes have the

fundamental limitations in obtaining high-resolution images due to the lateral resolution limit determined by the diffraction limit.
In this investigation, we propose high-resolution optical sectioning structured illumination microscopy (HROS-SIM), combining super-resolution structured illumination microscopy (SR-SIM) and optical sectioning structured illumination microscopy (OS-SIM).
SR-SIM overcomes wide-field microscopy limitations by creating Moiré fringes through the overlapping of specimen shape and illumination pattern. Rotating the illumination pattern captures fringes in all directions, synthesizing images in the optical frequency domain.
By axially scanning the specimen, OS-SIM measure the visibility curve of the illumination pattern at every pixel, and the 3D image of the specimen is reconstructed. Combining SR-SIM and OS-SIM results enable the obtain of high-resolution 3D images. To experimentally verify the system performance, various step height standard specimens were measured, and the results were compared with those by the conventional ways

Keywords: Structured illumination microscopy, High lateral resolution, Digital micro-mirror device

ASPEN2023P_074

Roughness Analysis Method of Polarization Lateral Shearing Interferometry

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Abstract

In this investigation, we propose a snapshot roughness measurement method based on the measurement result of a polarization lateral shearing interferometer. The proposed method can calculate various roughness parameters from a sheared interferogram without any sophisticated surface reconstruction algorithms. In addition, a compact polarization lateral shearing unit with a polarization camera is designed to simultaneously obtain four phase-shifted interferograms by a single acquisition. To generate two laterally-sheared wavefronts, we use a polarization grating and a flat mirror, which can be adaptable to the typical imaging system. Moreover, it is very insensitive to vibration because it measures the interference signal generated based on self-interference and analyzes the roughness of the single image. The measured results were compared in the experiments with those of a white light scanning interferometer, and the proposed roughness measurement method was experimentally verified.

Keywords: Lateral shearing interferometry, Roughness, Polarization grating, Polarization camera

ASPEN2023P_090

Holographic Null Test for Corrective Machining of Monolithic Multiple Freeform Mirrors

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Abstract

Monolithic multiple freeform mirrors integrate two or more surfaces on a single substrate. Alignment of these surfaces is no longer required because they are frozen there as they are machined. Null test is then critical as a feedback to corrective machining which is indispensible for high accuracy optics. This paper presents a methodology for corrective machining of monolithic multiple freeform mirrors based on holographic null test capable of measuring multiple surfaces simultaneously. A single computer generated hologram is proposed with different regions to compensate aberrations of different surfaces. A combined tilt and power carrier is designed to separate the disturbance orders of diffraction. Mapping distortion in the null test is corrected through a pure ray tracing procedure by introducing a virtual reference sphere. The surface error including the orientation error is then superposed on the nominal surface to generate the tool path for corrective machining with fast axis servo. The tool radius and decenter is recognized by pre-cutting a spherical surface. The remounted workpiece is aligned with the

machine tool by using an on-machine probe. The proposed method is then experimentally verified by corrective machining monolithic two mirrors with surface error effectively reduced and null fringes observed for both surfaces. Another experimental case shows the capability of measuring monolithic multiple annularly folded mirrors for a visible-infrared imaging systems. Two CGHs are designed for null test of the monolithic primary/tertiary mirrors and the monolithic secondary/fourth mirrors. Ghost image of disturbance orders of diffraction is effectively separated by properly choosing the power carrier and the axial position of the CGH. The detection experiment for targets 100m away shows the mirrors have good imaging quality without additional alignment. It possesses the advantage of high integration, fast manufacture and high imaging performance.

Keywords: Free-form surface, Computer generated hologram, Null test, Diamond turning, Corrective machining

ASPEN2023P_118

Development of Rotational Motion Fourier Transform Spectrometer through Design optimization with 0.1 cm-1 Resolution

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Abstract

Fourier transform infrared spectroscopy based on Michelson interferometer has traditionally been widely used for trace gas detection. For high-resolution gas spectroscopy, a resolution of 0.1 cm-1 is required, which requires securing a scanning range of 100 mm or more in the interferometer. This fundamentally limits the miniaturization of the spectrometer because it is required to implement a stage for linear transfer of the long stroke of the measurement mirror in the interferometer. In order to solve this problem, we propose a method to secure the scanning range through a rotational motion with a pair of right angle mirrors rather than the linear transfer method of flat mirror. The optical path length of the measurement arm was modeled to calculate the scanning range by the rotational motion of the right angle mirror pair. We developed a compact FTS with a scanning range of 100 mm by design optimization through a pattern search algorithm. To evaluate the performance of the FTS, gas absorption lines were analyzed using a home-built infrared laser and a commercial hydrogen cyanide (H13C14N) gas cell.

Keywords: Fourier transform spectrometer, high-resolution spectroscopy, gas detection, femtosecond laser

ASPEN2023P_134

Development of a Novel on Machine Monitoring System in Ultra-precision Diamond Cutting

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Abstract

Ultra-precision machining technologies, including Nanomechanical processing, Nanophysical processing and Nanochemical or electrochemical processing have been widely used in advance optics, aerospace engineering and telecommunication for producing parts with high tolerance requirement (< 1 micro) and high surface finishing (sub micro to nanometer level) as well as difficult to machine materials which are unable to be processed through conventional machining. Ultra-precision diamond cutting, which is a type of nanomechanical process, requires an on-machine monitoring system to closely monitor different cutting parameters in order to identify process errors and failures at an early stage thus minimizing the negative impacts during machining process which allows in process correction and rework which reduces material waste as well as prolong tool life. In this paper, a novel

setup on machine monitoring system is developed for the collection of o data about process conditions such as cutting force, chatter, shearing strain, chip velocity, tool centering, surface morphology etc.

ASPEN2023P_183

Target-recognition-assisted Smart 3D Measurement of Multi-layered Glass Based on Autostereoscopic Technologies

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Abstract

Multi-layered glass structure is widely used for the manufacture of various precision electronic components. Defects such as impurities, cracks, bubbles, etc. arise during the production process of multi-layer glass and are distributed in different layers or between layers of its internal structure. The identification and the dimensional measurement of these defects definitely affect the product function and the control of production costs and efficiency . In this sense, rapid and accurate 3D measurement of the above-mentioned information is vital to reduce the failure rate during manufacturing. However, conventional measurement systems usually require moving the target sample vertically, which severely affecting the measurement efficiency and impose extra measurement uncertainty. To tackle these key issues of measurement problems, a three-dimensional optical measurement system based on autostereoscopic technologies was proposed and developed accordingly with the aid of deep-learning-based target recognition technologies. The proposed measurement system is able to automatically identify the region of interest (ROI) with smart target recognition algorithm. The elemental images that are recorded by the autostereoscopic 3D measurement system incorporates a microlens array, can be refocused as multi-focus images via the multi-viewpoint and multi-depth information. The multi-focus images are processed by self-developed shape from focus algorithms so that the 3D information of the measured defects can be extracted directly with sub-micrometer form accuracy and millisecond-level measurement speed. Preliminary experiments have been conducted to measure the glass panels for mobile phones. The results show that the proposed system could perform the whole measurement process including locating the ROI and achieve sub-micrometer accuracy of the defect's 3D information, which also verify the feasibility of the proposed measurement method and the system to perform smart and efficient 3D measurement.

Micro/Nano Fabrication Processes

ASPEN2023P_056

Electrical Properties of Silver Nanowires Prepared by Nanoskiving Approach

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Abstract

As a kind of nanostructure with an ultra-high aspect ratio, nanowires have shown wide application prospects due to their excellent mechanical, electrical, and optical properties. The excellent conductivity and light transmittance of silver nanowires make them a darling in the field of flexible transparent electrodes, which greatly promotes the development of wearable flexible electronic devices. However, the existing methods for preparing ultralong silver nanowires are limited by poor controllability or high preparation cost. As a simple and effective new nanofabrication method, nanoskiving has been proven to be used for the preparation of ultralong nanowires. Herein, silver nanowires are prepared by the nanoskiving method, and their electrical properties are tested by the two-point electrical measurement method. The morphology and integrity of the nanowires were characterized by scanning electron microscopy. Polymers around silver nanowires are removed by argon plasma. The current-voltage curve of Ag nanowires is obtained by a two-end measurement method. The resistivity of silver nanowires with a height of 80 ~ 200 nm, width of 160 nm, and 208 nm is analyzed. The resistivity of nanowires is in the range of 5~25×10-8Ω□m, which is higher than that of bulk silver (1.65 × 10-8Ω□m). The failure current of silver nanowires increases with the increase of its height, but the failure current density decreases. The failure current of silver nanowires increases with the increase of its height, whereas the failure current density decreases. This study guides the design and preparation of microelectronic functional devices based on silver nanowires.

Keywords: Nano-cutting, Nanoskiving, Nanowire, Electrical property

Molding and Forming Technology

ASPEN2023P_053

Fundamental Study on Influence of Ground Surface Characteristics on Mold Releasability in Compression Molding of Thermosetting Phenol Resin

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Abstract
In the compression molding of thermosetting resins, surface characteristics of the metal molds, such as wear resistance, corrosion resistance, and mold releasability, are important for stable mass production of high-quality products. The surface treatments are generally applied to improve the surface characteristics of the metal molds. However, thickness of the surface treatments is limited to only a few μm since the surface treatments should guarantee surface shape accuracy of the metal molds. Therefore, finished surfaces of the metal molds often affect the mold releasability. In this study, the mold releasability of the ground surfaces was experimentally investigated. A thermosetting phenol resin was compression-molded onto the ground surface with different surface roughnesses. Then, the influences of surface characteristics on the mold releasability from ground surfaces were discussed by measuring tensile load when the molded resin was vertically separated from the ground surface as the mold release force. As a result, it was found that there was a maximum height roughness Rz of the ground surface where the mold release force became lower. Then, anchor effect between the molded resin and ground surface, and cohesive failure of the molded resin were considered as the mold release factors.

Keywords: Mold releasability, Ground surface, Surface roughness, Compression moldin

ASPEN2023P_133

An Investigation of the Precision Hot Embossing Process for Micro-nano Structured Surfaces on Chalcogenide Glass

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Abstract
To fabricate high precision chalcogenide glass (ChG) nanostructure array, hot embossing process (HEP) experiments are carried out to analyze the element diffusion mechanism between ChG and the mold. Micro-nano structured surface is fabricated on the ChG by HEP. First, the ChG embossing experiment is carried out with nickel phosphorus (Ni-P) coating mold. The diffusion of atoms between the ChG and Ni-P coating in high temperature and high-pressure is analyzed. Optical glass used as the intermediate mold for ChG embossing is also put forward. Second, fly cutting is used for ultra-precision machining the mold with large area structural color, and structural color surface on optical glass is then fabricated by HEP. Finally, micro-nano structure array is embossed on ChG by optical glass mold, the structural color characteristic of workpiece is evaluated.

Keywords: Chalcogenide glass, Hot embossing process, Micro-nano structures, Structural color, ultra-precision machining

Non-traditional Machining

ASPEN2023P_011

A Study for Uniform Laser Hardening of Steel Parts with Convex and Concave Corners

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Abstract
The objective of this study is to establish a laser hardening technique to uniformly harden the entire surface of stepped shafts. In our previous study, an investigation on the laser hardening for a straight steel shaft was conducted, and an all-round hardening method using a high-speed scanning laser and a cylindrical inner mirror was proposed. As a result, it was confirmed that a hardened area could be formed around the entire circumference of the shaft without soft zones, which had been a big problem with conventional methods. In this study, a workpiece with a staircase shape was targeted prior to the study for the convex and concave corners part of a stepped shaft. A method changing the laser irradiation conditions according to the difference in the heat capacity of the laser irradiated area was devised, and the effectiveness of this method was verified both experimentally and theoretically.

Keywords: Laser, Heat treatment, Hardening, Convex and concave corners part, Stepped shaft

ASPEN2023P_013

Applications of Ultra-precision Mechanical Cleavage Technology on Semiconductor Lasers with Broad Area Mirror Facets

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Abstract
As a novel technology for high-power semiconductor lasers with broad area mirror facets, mechanical cleavage technology has received extensive attention. The scribing step plays a critical role in the follow-up breaking step to create high-quality cavity mirror. However, there are still a lot of technical gaps to be filled at this stage. In this study, an edge-scribing method was proposed based on finite element simulation. The scribing energy of the edge-scribing and traditional scribing methods along the [0-1-1] directions were calculated and analyzed regarding energy consumption. The formation of cleaved mirror facets of GaAs-based laser bars was investigated using edge-scribing and traditional scribing methods. The results show that the edge-scribing method can significantly reduce energy consumption during the cleavage of GaAs, and the energy saving ratios exceed 70%. The surface roughness (Ra) of the obtained cleaving mirror facets by the edge-scribing method can achieve 0.43 nm.

Keywords: Ultra-precision machining, Mechanical Cleavage, Semiconductor Lasers, GaAs, Mirror Facet

ASPEN2023P_023

Passivation and De-passivation in ECM: Fundamentals and Applications

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Abstract
Passivation is a common phenomenon in electrochemical machining (ECM) as a side reaction of anodic dissolution. It is essential to understand and control the fundamental anodic oxidation/passivation mechanisms to advance ECM technologies. On one hand, anodic oxidation can be beneficial to producing uniform (bath anodization) or localized (by electrochemical jet anodization, EJA) oxide films

for surface masking or protection, and for patterning, i.e., lithography applications. On the other hand, the passive film must be overcome in ECM of strongly passivating materials to achieve material removal. The work here demonstrates the control of passivation and de-passivation process to further develop EJM technique.

Keywords: Passivation and de-passivation, Electrochemical jet anodization, Electrochemical machining

ASPEN2023P_040

Feasibility Study of Ultrasonic Vibration Assisted Grooving for Zirconia Ceramics

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Abstract

Zirconia (ZrO2) ceramics are widely utilized in aerospace, biotechnology, and other industrial fields due to their exceptional material properties. However, it is challenging for conventional grinding (CG) to meet industrial requirements due to its inherent hardness and brittleness. To address this issue, we proposed tilted grooving (TG), which has been experimentally proven to effectively reduce grinding forces, and thus can reduce wheel wear. However, due to the inclination of the grinding wheel axis, the value of machined surface roughness of TG is greater than that of CG. Ultrasonic-assisted machining is a well-recognized method for enhancing surface quality and extensively applied in the precision machining of hard and brittle materials. Therefore, we combine these two approaches and introduce a novel method, called ultrasonic vibration-assisted tilted grooving (UVTG), for ceramic part fabrication. First, the motion trajectory of a single abrasive grain is derived based on its kinematics. Then, the apparatus of UVTG is developed according to its processing principle, and some experiments are conducted. The experimental results validate that UVTG can effectively reduce grinding forces and surface roughness, thereby affirming the feasibility of UVTG for ZrO2 ceramics.

Keywords: Zirconia ceramics, ultrasonic vibration-assisted tilted grooving, grinding force, surface roughness

ASPEN2023P_058

Research on the Grindability Improvement of Titanium Alloy by Ultrasonic Assisted Plasma Oxidation

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Abstract

In this study, the ultrasonic vibration assisted plasma oxidation and grinding (UAPAG) technology was proposed to improve the grinding performance of the titanium alloys. In this study, the machining principle and experimental device of UAPAG were introduced firstly. Secondly, the effects of different electrolytes on growth direction of the oxidized layer and process parameters on thickness of the oxidized layer were studied. Then, the mechanical properties of the oxidized layer were characterized, and the material removal behavior of the oxidized layer was revealed by single point grinding experiment. Finally, the machining performances of Ti-6Al-4V were compared between the conventional grinding (CG) and UAPAG. The results show that the oxidized layer mainly grows inward under the Na2SO4 electrolyte, and the slower feed rate and higher ultrasonic vibration amplitude give rise to the much thicker oxidized layer. Through the single point grinding experiment, it was found that the lower microhardness of the oxidized layer with many cracks improves the grindability of titanium alloy. Compared with CG of Ti-6Al-4V, UAPAG can reduce the grinding force, improve the quality of the ground surface, and reduce the chip adhesion on the grinding wheel.

Keywords: Titanium alloy, Ultrasonic vibration, Plasma oxidation, Oxidized layer, Grindability

ASPEN2023P_061

Autonomous Generation Process of Nano- and Micro-textured Surfaces by Molecular Beam Epitaxy Using a Helicon Sputtering Molecular Beam Source

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Abstract
The miniaturization and lightweight design of devices, such as smartphones, have brought about numerous benefits to people, including energy savings and increased efficiency. To achieve this, mechanical structures must be scaled down to micro and precision levels. Micro-textured surfaces with regular shapes of micro-units, such as cylinders or line and space, hold potential benefits, such as energy savings and efficient resource utilization. Therefore, it is desirable for surfaces to possess ultra-smooth and/or nano-micro-textured properties. However, due to their precision and small size, these surfaces are challenging to fabricate using mechanical machining.

In this study, we aimed to generate micro-textured surfaces using molecular beam epitaxy (MBE) with a helicon sputtering molecular beam source. MBE is an epitaxial growth process that can produce a uniform single-crystal thin film by depositing each molecular layer on a specific single-crystal substrate surface. Prior to MBE, we patterned the substrate with micro-circular holes or cylinder shapes as pre-patterns. These pre-patterns can create a potential energy difference on the surface and serve as a starting point for epitaxial growth, making them the ideal starting point for micro-textured surfaces.

To understand the generation process of micro-textured surfaces, we observed each deposition time. This allowed us to clarify the factors influencing the formation of the micro-textured surfaces

Keywords: Micro-textured surface, Epitaxial growth, Helicon sputtering

ASPEN2023P_077

A Study of Magnetic Field-assisted Batch Polishing on Structured Surfaces

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Abstract
With the increasing demand for structured surfaces in different fields such as optics, biomedical, physics etc., a cost-effective and highly efficient polishing process is needed to increase the productivity in removing defects on the machined structured surface, meeting the surface quality and accuracy requirements for functional purpose. A magnetic field-assisted batch polishing (MABP) was proposed to polish the structured surface at once with high efficiency. Experimental studies were conducted on four types of structured surfaces which were fabricated by milling, including v-grooves, sinusoidal grooves, rectangular grooves, and micro-channels. The surface roughness, form accuracy and surface topography before and after polishing were compared and analyzed. The results indicated that MABP can achieve nanometric surface roughness and remove machining tool marks in the abovementioned structured surfaces while maintaining surface form accuracy within 1 μm, demonstrating the high efficiency and feasibility of MABP on superfinishing of structured surface polishing.

Keywords: Magnetic field-assisted, mass finishing, structured surface, microstructure, polishing

ASPEN2023P_135

Experimental Study on 4H-SiC Magnetic Field-Assisted Ultra-precision Grinding

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Abstract

Silicon carbide (SiC) is a third-generation semiconductor material used in high-performance power electronics, but it is extremely difficult to cut because it is a hard and brittle material. Ultra-precision grinding (UPG) is a machining technology that enables difficult-to-cut materials to achieve nanometer surface roughness and submicron shape accuracy without the need for subsequent machining. However, when machining SiC using UPG, various machining and material intrinsic factors such as grinding temperature, grinding wheel vibration, tool wear, tool shank material, material removal rate, material expansion and rebound have potentially significant impacts on machining SiC surfaces. To obtain better SiC surface integrity, this paper proposes a new machining method by adding a magnetic field in UPG. Based on the theory of magneto-plasticity and electromagnetic induction, the effect of magnetic field on various machining and material intrinsic factors when grinding 4H-SiC was experimentally investigated. Meanwhile, the material removal mechanism of magneto-plastic 4H-SiC and the application of magneto-plasticity in 4H-SiC machining are investigated using scratch experiments, demonstrating the positive potential of magnetic field-enhanced plasticity (i.e., magneto-plasticity) in improving plastic-brittle transition and machinability.

ASPEN2023P_136

Phenomenon and Mechanism of Shape Transition During the Ablation of WC Ceramic by Picosecond Laser

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Abstract

Tungsten carbide (WC) has gained extensive attentions during the past decades due to its excellent properties such as superior hardness, strength, wear resistance and so on. However, the outstanding properties of WC also make the material hard to machine. Different to traditional grinding and electro-discharge machining methods, the ultrafast laser machining has many particular advantages including non-contact, no mechanical force, no wear, high metal removal rate and so on, making ultrafast laser machining a novel approach to machine hard materials like WC with high precision. Nevertheless, existing studies about ultrafast laser machining of WC mostly tended to recognize the ablation threshold as a certain value. Little attention has been paid to the fluctuation of ablation threshold itself. As a consequence, phenomena including the shape transition of ablated zone found in this study were hard to be explained by the existing theories. Therefore, experimental and numerical methods were combined in this study to further clarify the change of threshold as well as the shape of ablated zone. This study enhanced the understanding of material removal mechanism during ultrafast laser ablation of WC, which was significative for achieving better quality and efficiency on machining hard materials by ultrafast laser ablation.

Keywords: Tungsten carbide, Ultrafast laser, Shape, Ultra-precision machining

ASPEN2023P_140

The Laser Surface Treatment of Polycrystalline Diamond Wafers

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Abstract

The ultraviolet laser was applied for the polycrystalline diamond (PCD) wafers fabricated by physical vapor deposition (PVD) to improve the machinability of PCD wafer. Laser surface treatment experiments with line scanning mode were conducted to investigate the microgroove morphology. The influence of laser scanning velocity on the microgroove morphology was studied. The width and depth of microgroove decreased with the increasing of laser scanning velocity. The ratio of width and depth increased with laser scanning velocity. The laser oscillation technology was used to modify the

microgroove morphology. The laser oscillation increased the width and depth of the microgroove. Besides, the laser oscillation weakened the influence of laser scanning velocity on the ratio of width and depth. Finally, laser surface treatment experiment with area scanning mode was conducted. The surface roughness of laser-treated surface decreased compared to the base material surface.

Keywords: Polycrystalline diamond, laser surface treatment, microgroove, ratio of width and depth, surface roughness

ASPEN2023P_187

Study on the Effect of Photoelectric Field on Photoelectrochemical Mechanical Polishing of GaN

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Abstract
Gallium nitride has promising applications in optoelectronic, high-power, and high-frequency devices owing to its excellent properties of wide band gap, stable crystal structure, high thermal conductivity, high temperature resistance, and good chemical stability, which is one of a wide range of materials. However, due to the high hardness and high chemical stability of gallium nitride, the traditional polishing method, chemical mechanical polishing, is extremely inefficient. Photoelectrochemical mechanical polishing is a processing method that can greatly improve the material removal rate under the assistance of multi-energy fields. This paper studies the influence of light field and electric field on the photoelectrochemical mechanical polishing efficiency of gallium nitride wafers. The experimental results show that: under the same light intensity and electric field intensity, it is easier to form an oxide layer under short-wavelength illumination; under the same light wavelength and electric field intensity, the stronger the light intensity, the easier it is to form an oxide layer on the wafer surface; Under the same light wavelength and light intensity, the stronger the electric field intensity, the easier it is to generate an oxide layer on the wafer surface.

Keywords: gallium nitride, photoelectrochemical oxidation, photoelectrochemical mechanical polishing

ASPEN2023P_191

Study on Polishing Mechanism of Diamond Utilizing Reaxff Simulations

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Abstract
Recognizing the limitations of classical molecular dynamics (MD) in describing chemical reactions and the constraints of small-scale first-principles simulations, we incorporated the ReaxFF MD metho into diamond simulations. This allowed us to establish an MD model for diamond processing. We conducted an analysis of the material removal mechanism and the damage evolution mechanism under the influence of a multi-energy field. Additionally, we examined the atomic removal mechanism, the form of material removal, and the chemical interactions involving the polishing fluid.

Keywords: diamond, polishing, ReaxFF MD, mechanism

Precision Machine Design

ASPEN2023P_051

Influence of Fluid-Structure Interaction and Eccentricity on the Aerostatic Guideway's Lateral Stiffness

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Abstract
The static performances of the aerostatic guideways are affected by the fluid-structure interaction (FSI) effect and eccentricity due to the gravity. However, the influence of eccentricity on stiffness is often ignored in previous studies. The main reason is that the eccentricity's influence on the conventional horizontal guideway's stiffness is not significant due to its high vertical stiffness. In this paper, a fast calculation method is used to study the lateral stiffness of a special vertical aerostatic guideway, for which the eccentricity cannot be ignored. The optimal stiffness considering FSI effect and eccentricity decreases significantly compared with the ideal values. And the accuracy of the calculation results is verified by the conventional two-way FSI calculation method.

Keywords: Aerostatic guideway, Optimal clearance, Fast calculation method, Fluid-structure interaction

Surface Properties and Characterisation

ASPEN2023P_027

Diamond Growth Mechanism on Machined Stainless-steel Surface

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Abstract
Chemical vapor deposition(CVD) is a well-established method for diamond coating. However, direct diamond deposition on a steel surface has been considered impossible. In contrast, we have recently shown that diamond can be directly deposited on a stainless-steel surface by drilling multiple regularly arranged pits. And we have researched for the reason why direct deposition is possible and showed that the Cr and Ni contained in stainless-steel has carbon diffusion barrier function. However, the mechanism by which the barrier function appeared by drilling has not been elucidated. We hypothesized that "Cr and Ni concentration is not homogeneous, with the surface exhibiting lower concentrations and higher concentrations towards the interior, and the drilling process makes it homogeneous." To verify this hypothesis, we measured and compared the compositions of the processed and unprocessed surface using energy dispersive X-ray spectroscopy. Additionally, diamond deposition experiments were conducted on both the processed and unprocessed surfaces, and the relationship between the quality of the diamond and the surface composition has been discussed.

Keywords: Diamond, CVD, Stainless-Steel, In-liquid Plasma

ASPEN2023P_100

Surface Structure Change According To Viscosity of UV Curable Resin Used for Nanowire Replication

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Abstract
A structure having a nano size is used as an important factor in various fields such as fuel cells, biological surfaces, electricity, and electronics, and is a technology that is in the spotlight. Nano-sized structures can be prepared by various methods such as lithography, sol-gel, and self-assembly. Among the methods through lithography, Nano imprint lithography (NIL) technology is a technology that creates nano-patterns as if stamping through roll pressure after coating resin cured by UV light, and has the advantage of being easy to manufacture at low cost. However, the NIL technology has a disadvantage that it cannot fabricate a structure with a high aspect ratio. The fabrication of nanowires, which are nano-sized high aspect ratio structures, can be made easily and at low cost by using Anodic Aluminum Oxide (AAO) as a substrate. AAO has many nano-sized holes and micro-sized heights, so it is possible to fabricate homogeneous high aspect ratio nanowires when used as a substrate. However, according to previous studies, when nanowires are created using an AAO substrate, when the aspect ratio is 5:1, patterns are formed without aggregation, whereas when the aspect ratio exceeds 15:1, the nanowires cannot stand upright due to the surface tension of the nanowires and do not stick to each other. It aggregates and forms a fine pattern. The resulting surface appears differently depending on the length of the nanowire, and the length of the nanowire has a high correlation with the viscosity of the resin used. In this study, a total of three resins, UV PDMS, 311RM, and S2, which show a clear difference in viscosity, are used as materials to roll press on the AAO substrate, and then UV light is cured to produce nanowires. In addition, the porous structure of the surface created by the aggregation of the produced nanowires was confirmed.

Keywords: Nano Imprint Lithography, High Aspect Ratio, UV PDMS, anodic Aluminum Oxide, Nano Wire

General Information

Official Language: English (No simultaneous interpretation will be provided)

Conference Site

21st Nov, The Hong Kong Polytechnic University

22nd – 24th Nov, Hotel ICON, 1/F, Silverox Ballroom

Registration

Date	Venue	Time
21 Nov	Ju Yin House Seafood Restaurant 4/F, Communal Building, The Hong Kong Polytechnic University	17:30-20:00
22 Nov	Hotel ICON 1/F, Silverbox Ballroom	08:15-08:30
23-24 Nov	Hotel ICON 1/F, Silverbox Ballroom	08:15-08:30

Registration Fee	
Delegate – Face to Face	HKD $5600
Student – Face to Face	HKD $3600
Delegate – Virtual	HKD $3600
Student – Virtual	HKD $2900

*On-Site: Available at registration desk (Credit card/ Cash)

*Receipt: Provided on request (Credit Card Payees - Payment acknowledgement email will be sent to registrants)

Conference Secretariat

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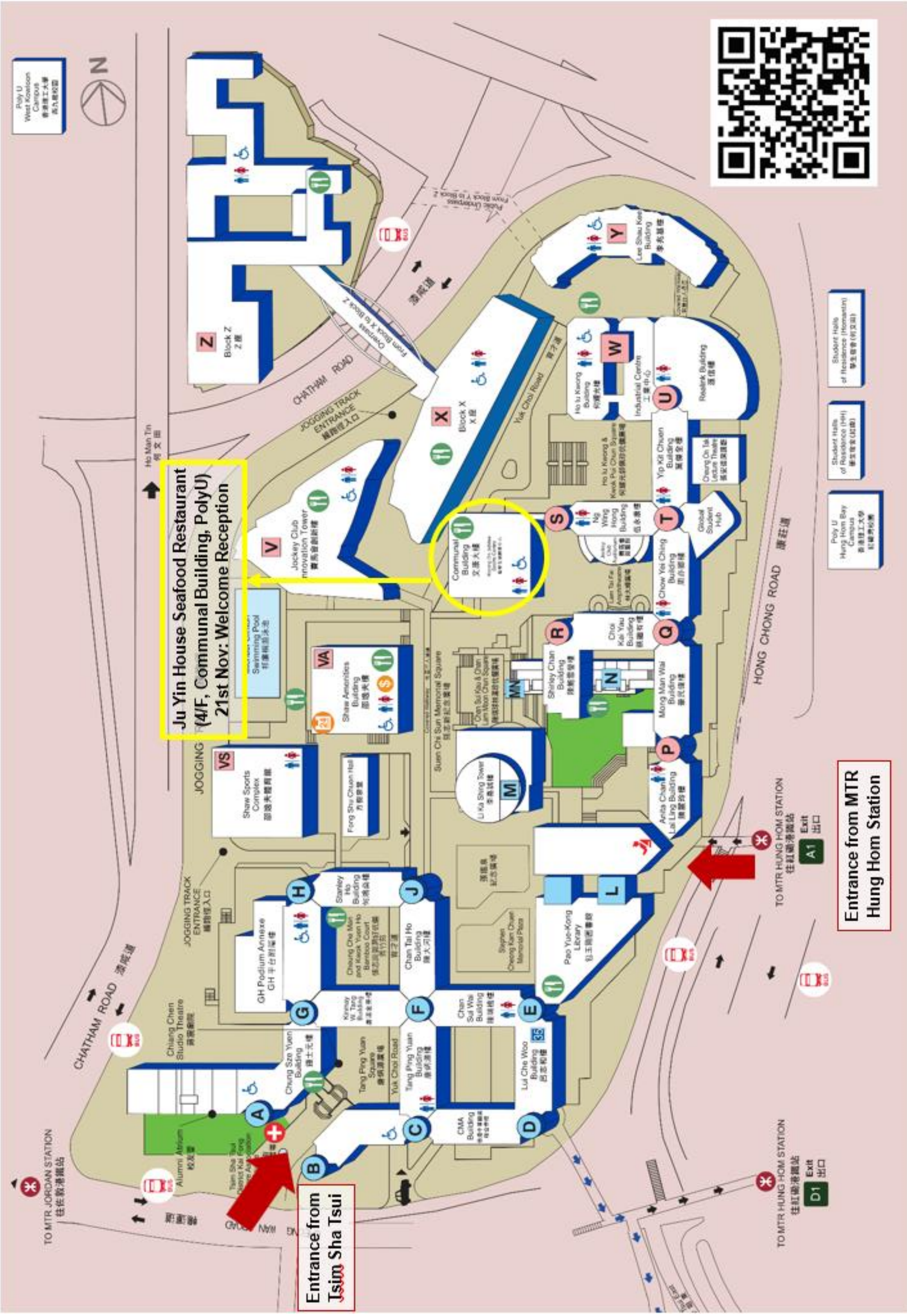
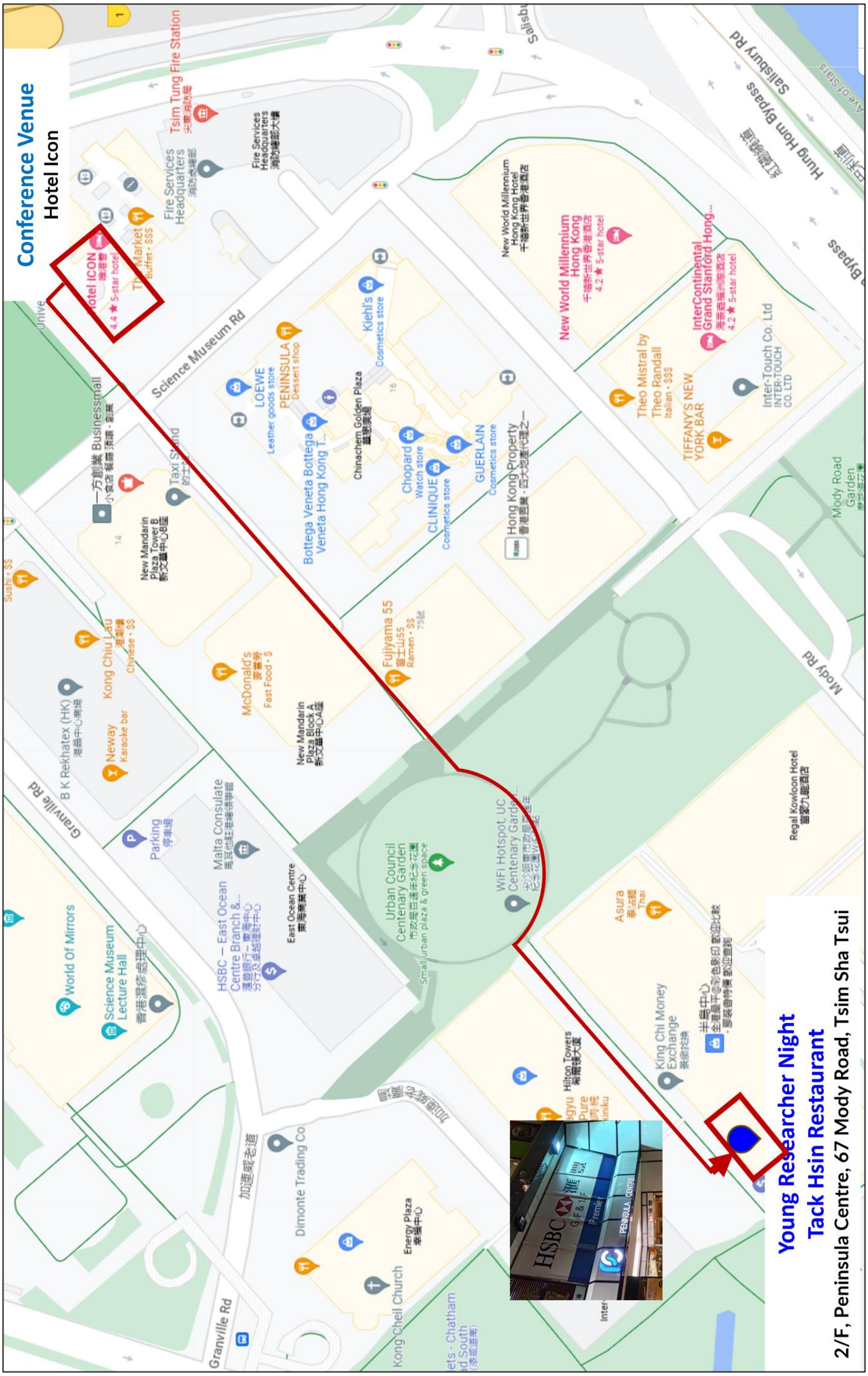
Email: aspen.2023.info@polyu.edu.hk
Contact number: +852-2766 6574 / +852-2766 6577

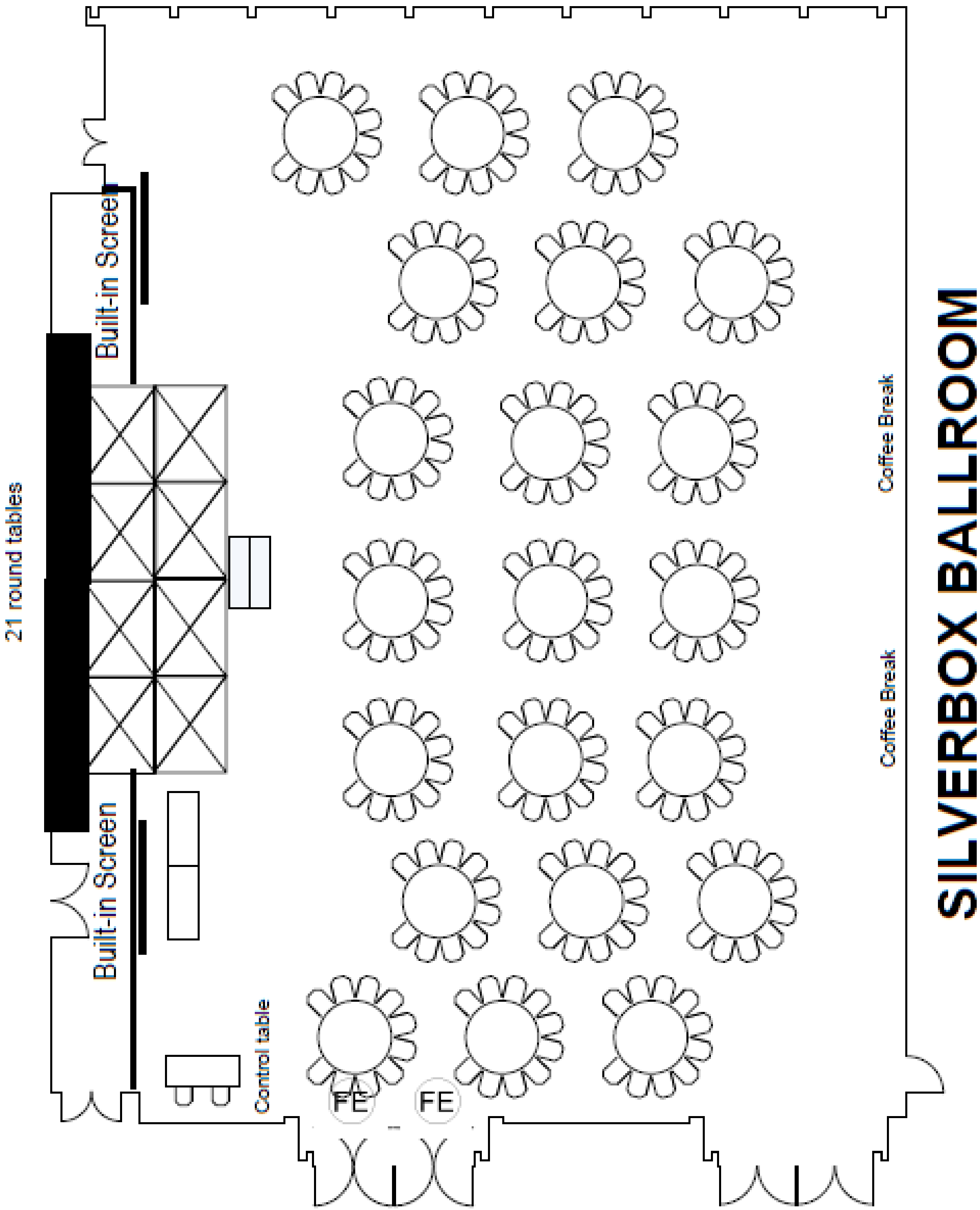
Campus Map of the Hong Kong Polytechnic University



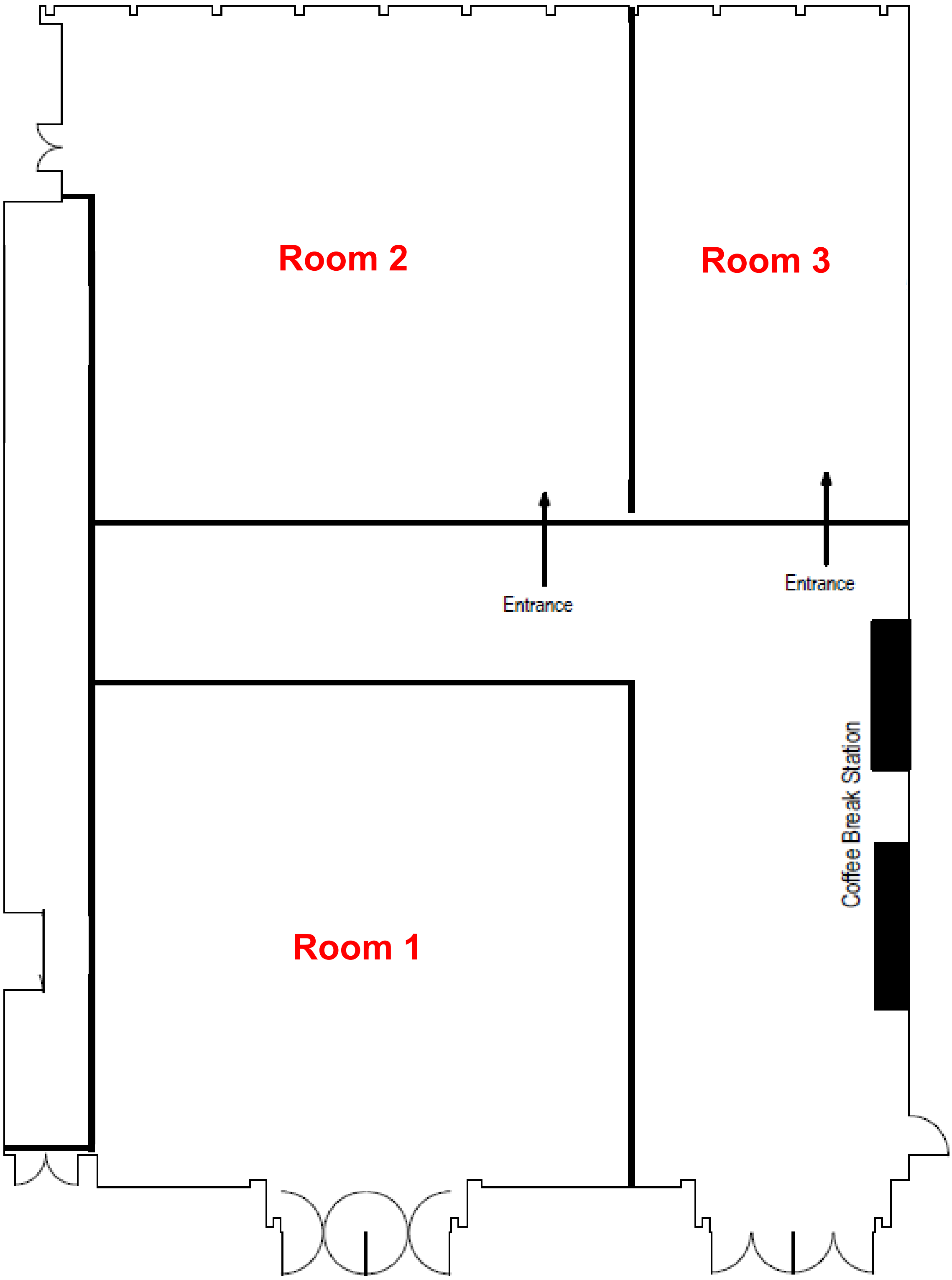
Map for Young Researcher Night



Floor Plan (22 Nov, Hotel ICON)



Floor Plan (23-24 Nov, Hotel ICON)



SILVERBOX BALLROOM